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(54) **MEDICAL INTERFACES AND OTHER MEDICAL DEVICES, SYSTEMS, AND METHODS FOR PERFORMING EYE EXAMS**

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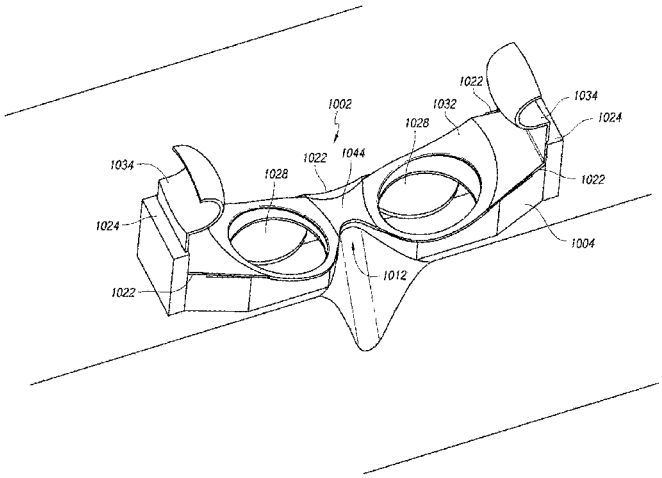
(57) **ABSTRACT**

A mask for performing an eye exam of a subject includes one or more optically transparent sections for transmitting an incident light beam therethrough and incident on the subject's eye. In some embodiments, the one or more optically transparent sections are coated with an anti-reflective coating configured to reduce reflection of the incident light beam by the one or more optically transparent sections. In some embodiments, the one or more optically transparent sections may have a portion thereof that is tilted with respect to the incident light beam when the mask is optically interfaced with the docking portion of an ophthalmic instrument, such that the incident light beam forms a finite angle of incidence with respect to the corresponding portion of the optically transparent sections.

14 Claims, 81 Drawing Sheets



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2016, now Pat. No. 11,039,741, application No. 17/064,249, which is a continuation-in-part of application No. 16/985,704, filed on Aug. 5, 2020, now abandoned, which is a continuation of application No. 14/852,379, filed on Sep. 11, 2015, now Pat. No. 10,772,497, application No. 17/064,249, which is a continuation-in-part of application No. 16/828,840, filed on Mar. 24, 2020, now abandoned, which is a continuation of application No. 14/984,035, filed on Dec. 30, 2015, now Pat. No. 10,631,725, which is a continuation of application No. 13/802,727, filed on Mar. 14, 2013, now Pat. No. 9,226,856.

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(58) **Field of Classification Search**
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See application file for complete search history.

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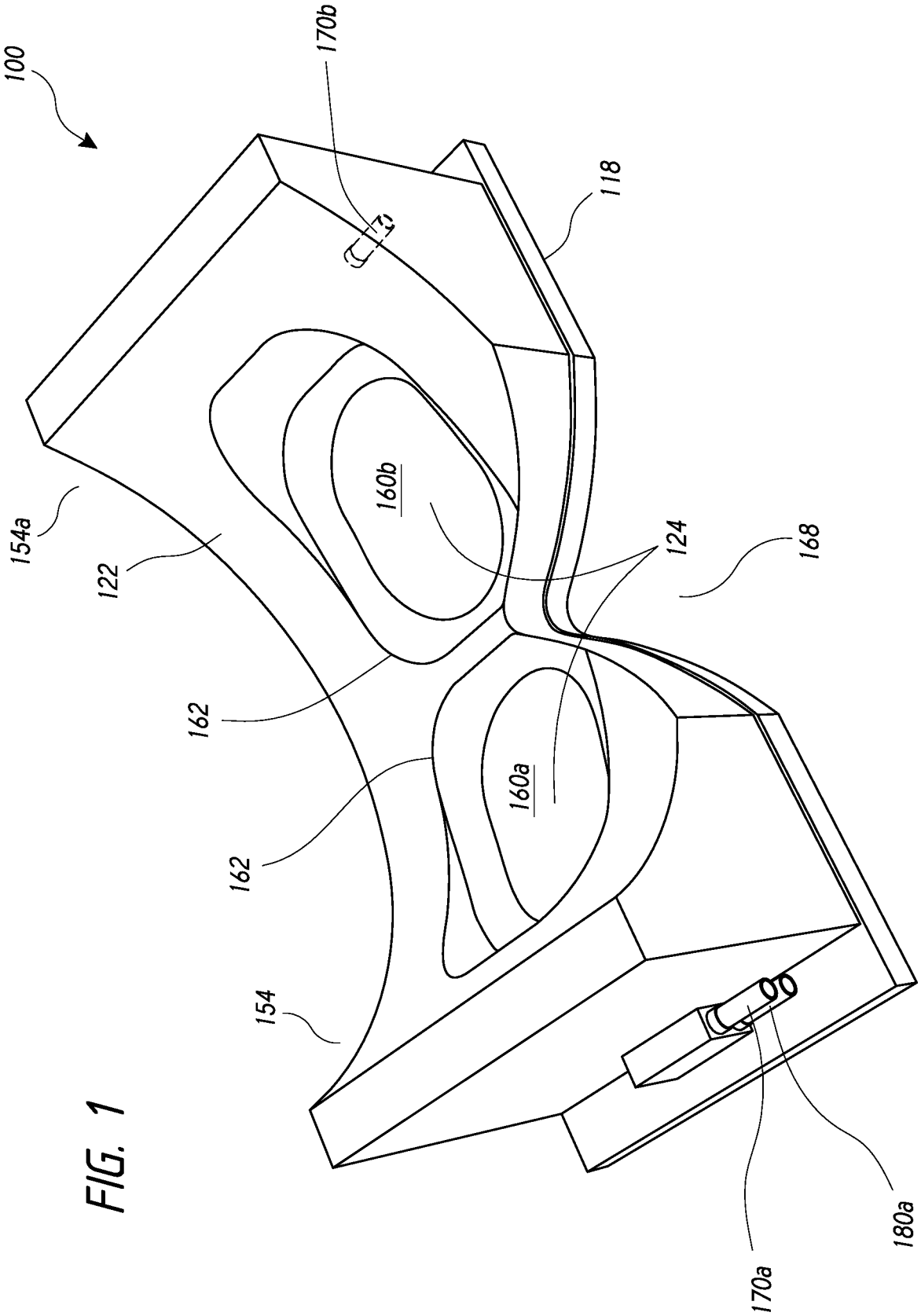


FIG. 1

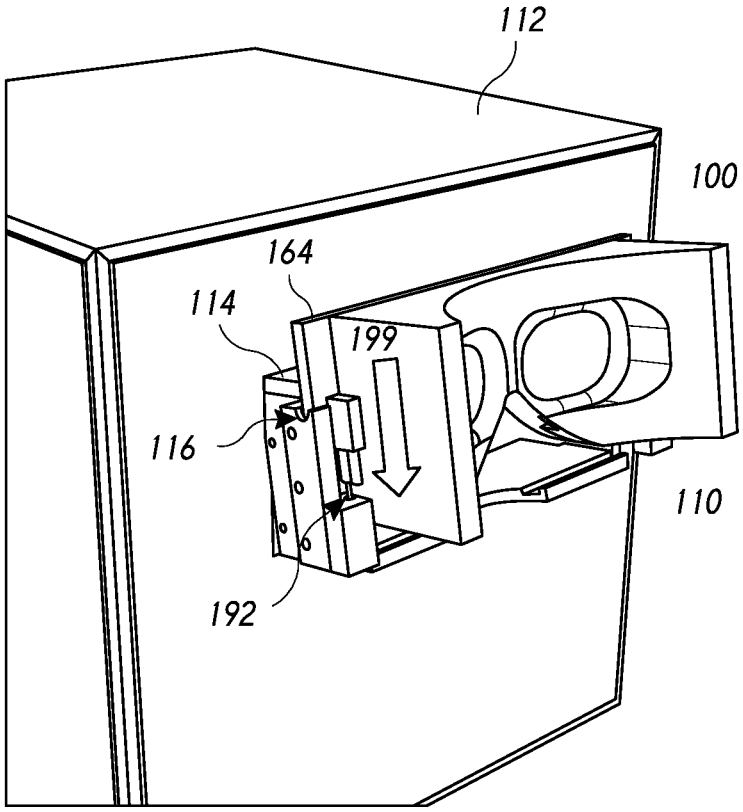


FIG. 2A

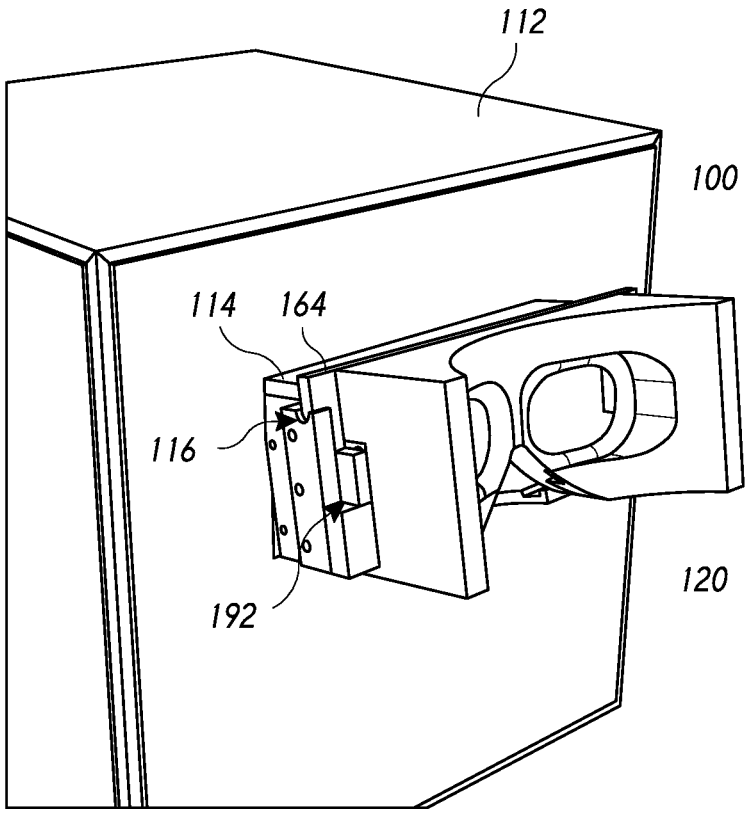


FIG. 2B

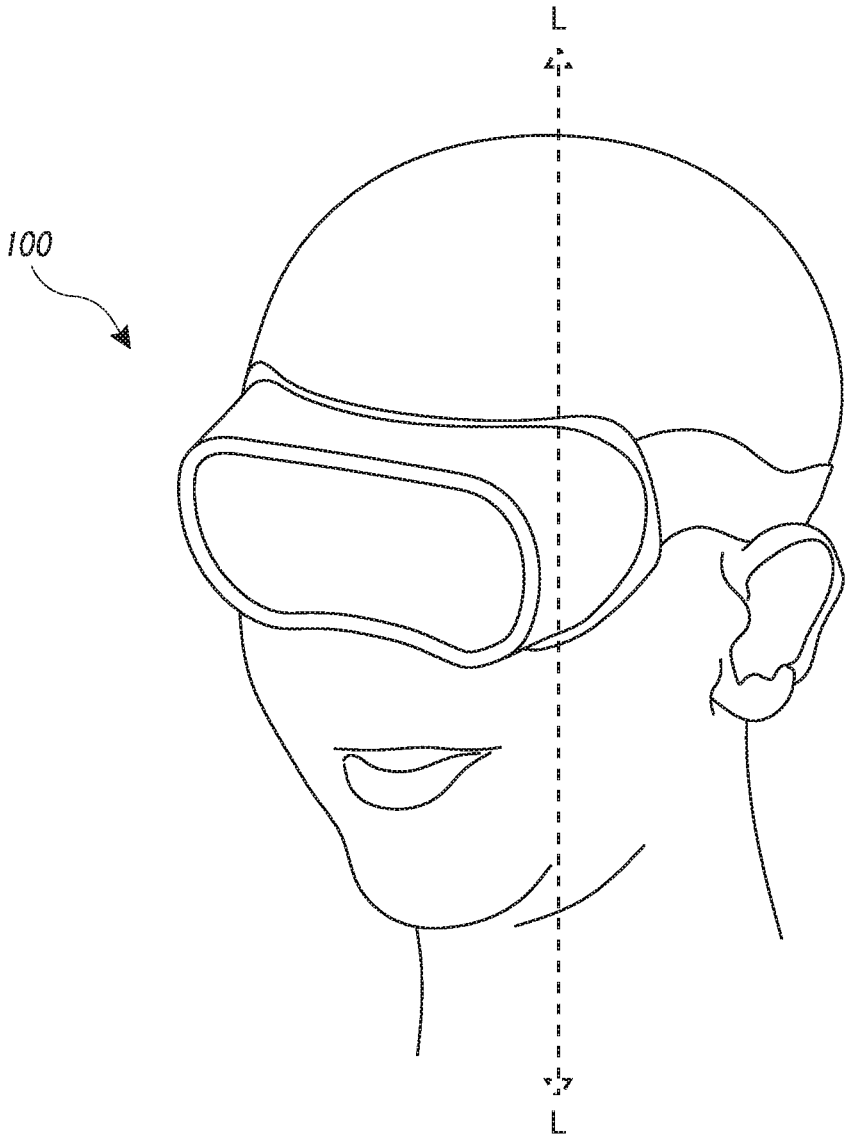


FIG. 3

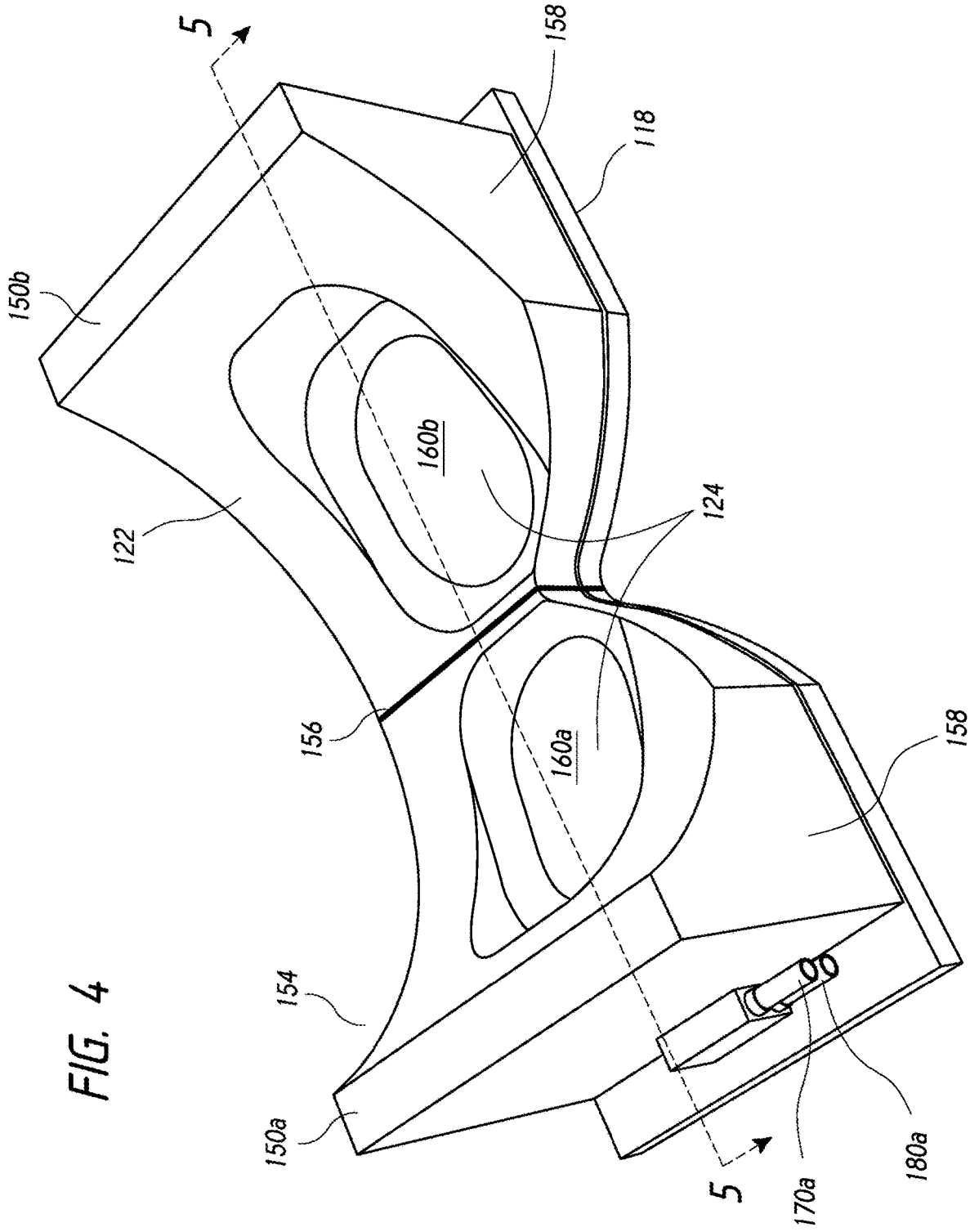
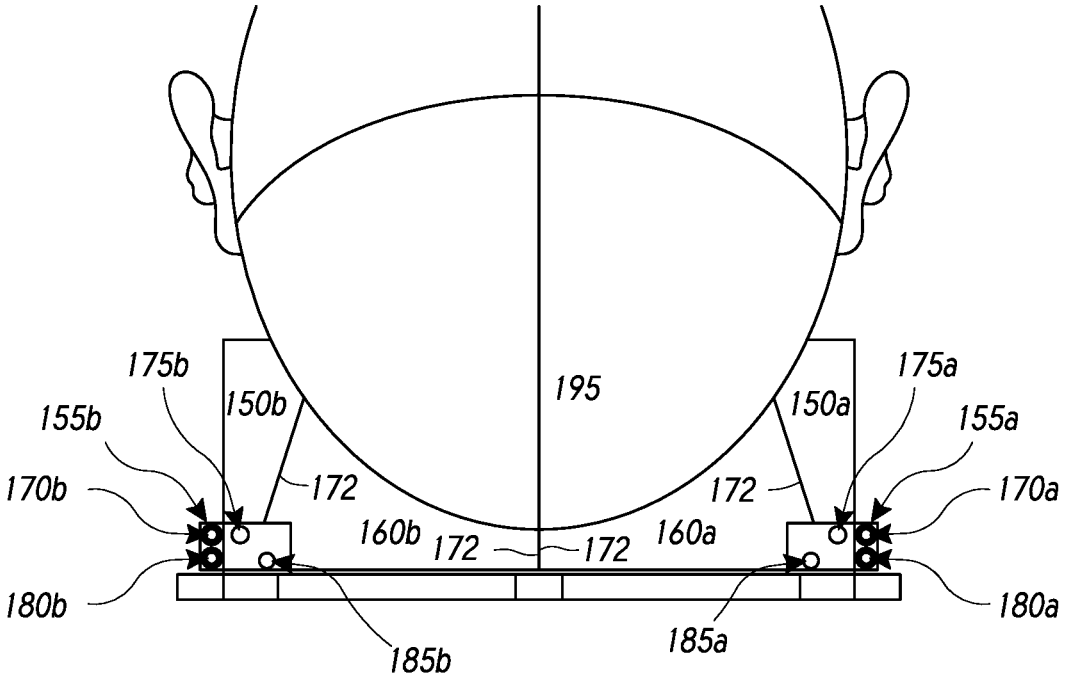


FIG. 4

FIG. 5


175b
150b
155b
170b
172
160b
172
172
160a
195
150a
175a
155a
170a
180b
185b
185a
180a

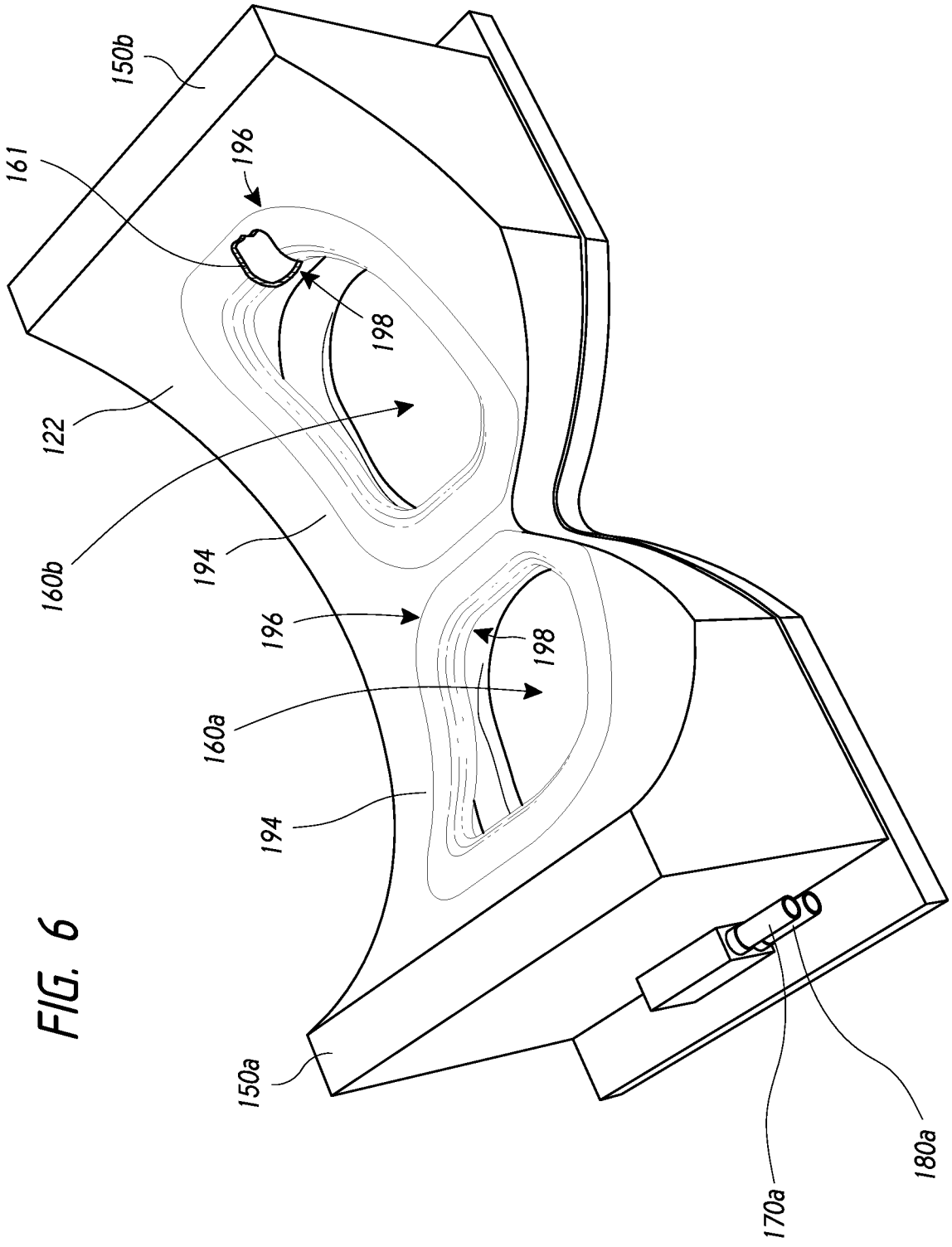


FIG. 6

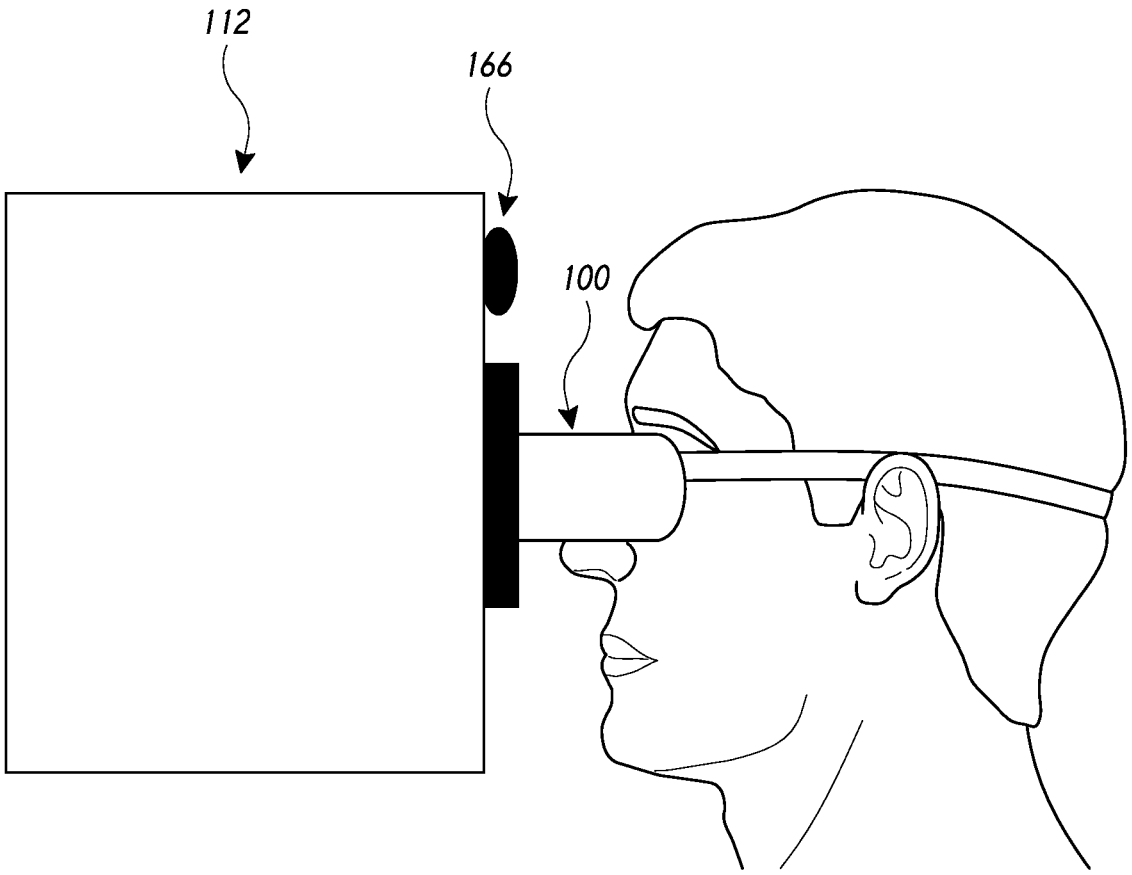


FIG. 7A

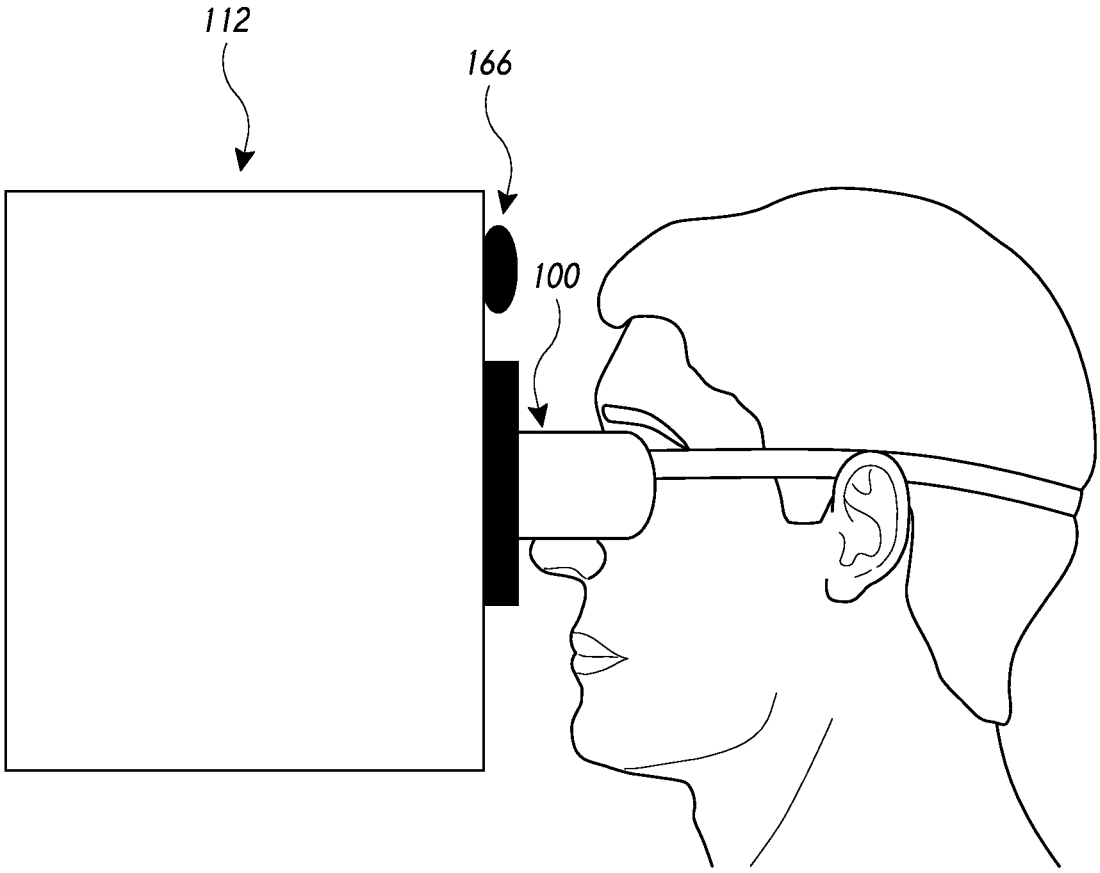
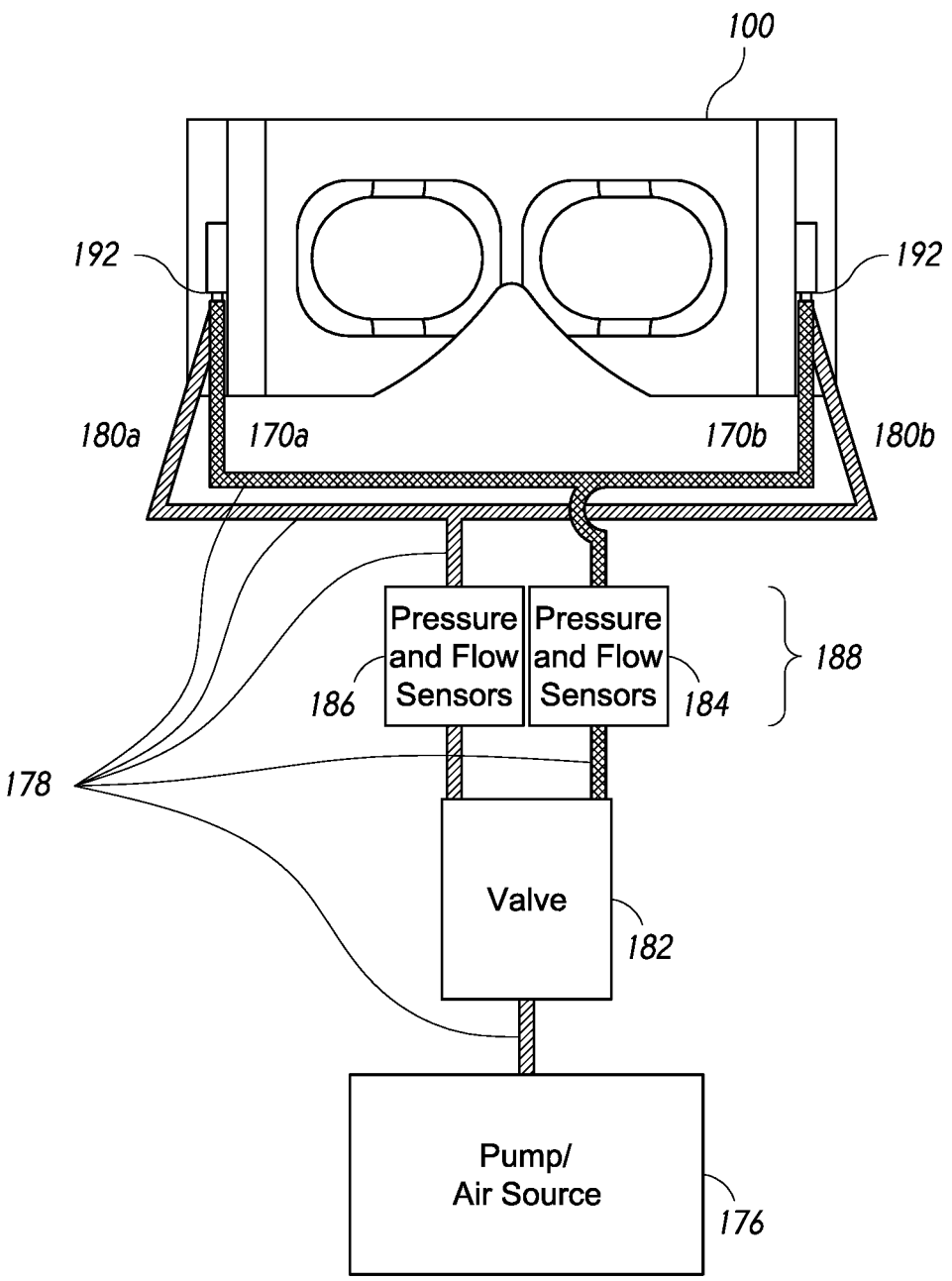


FIG. 7B

FIG. 8


174
100
192
192
180a
170a
170b
180b
Pressure and Flow Sensors
186
Pressure and Flow Sensors
184
188
178
Valve
182
Pump/ Air Source
176

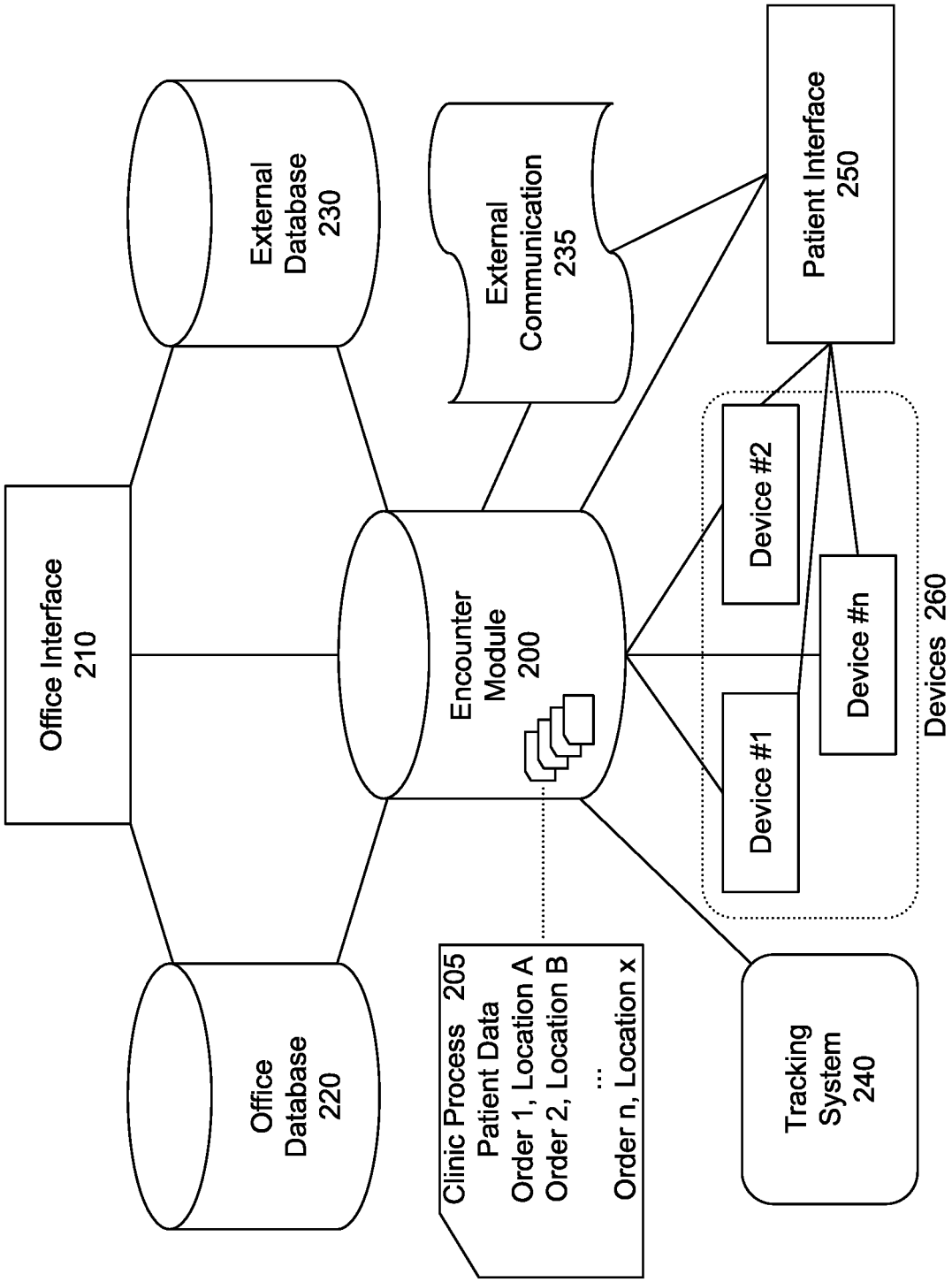

External Database 230
External Communication 235
Patient Interface 250
Office Interface 210
Encounter Module 200
Device #2
Device #1
Device #n
Devices 260
Office Database 220
Clinic Process 205
Patient Data
Order 1, Location A
Order 2, Location B
...
Order n, Location x
Tracking System 240

FIG. 9

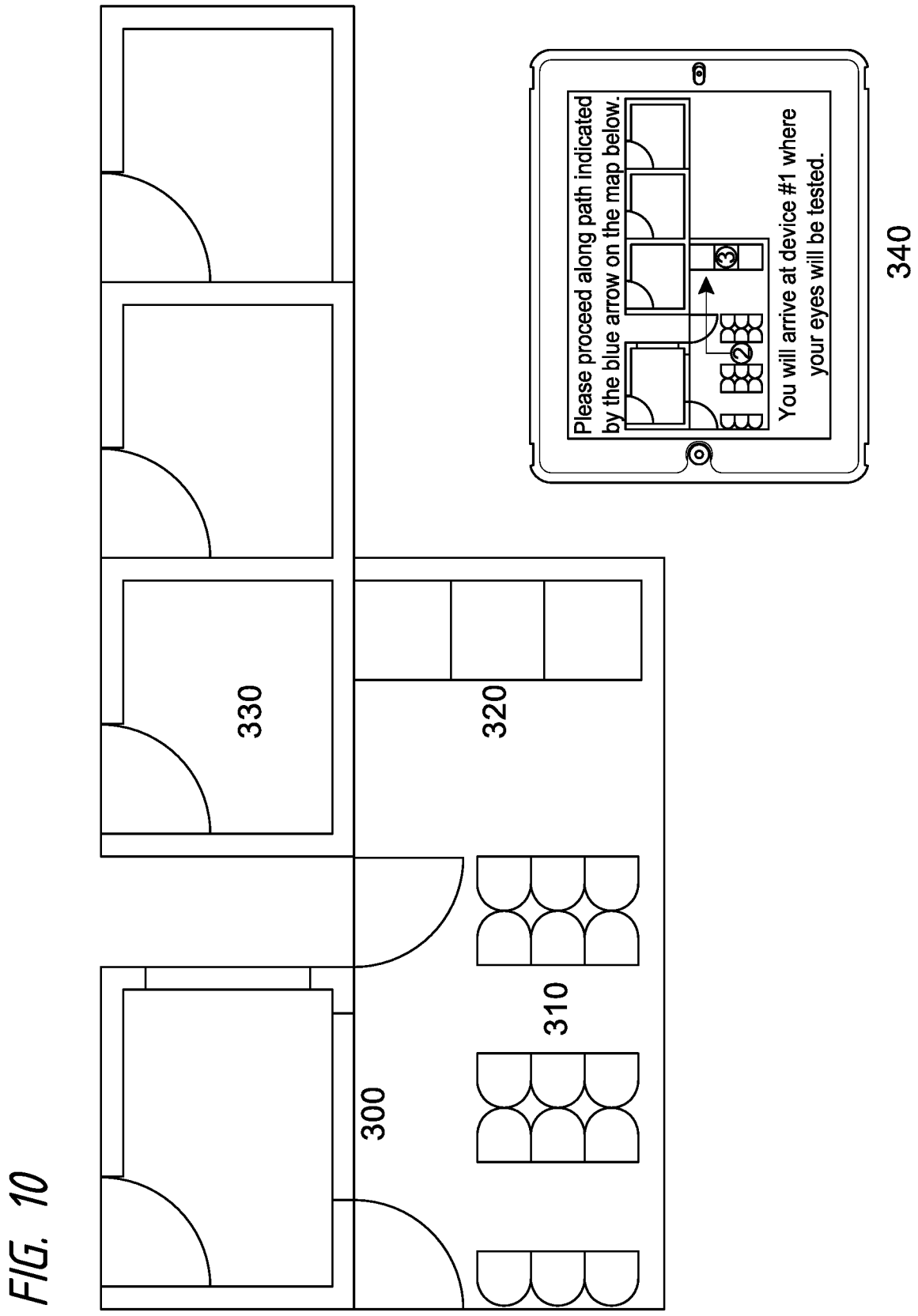
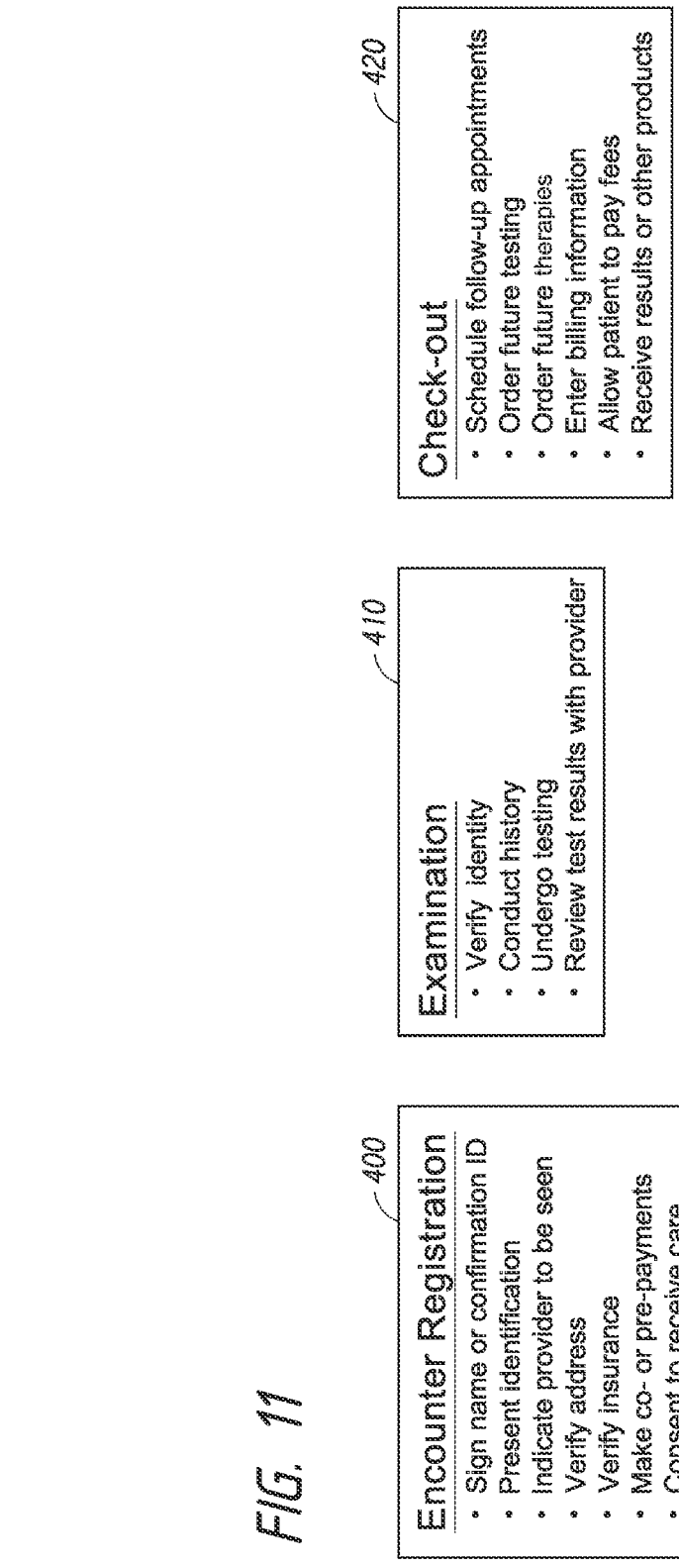
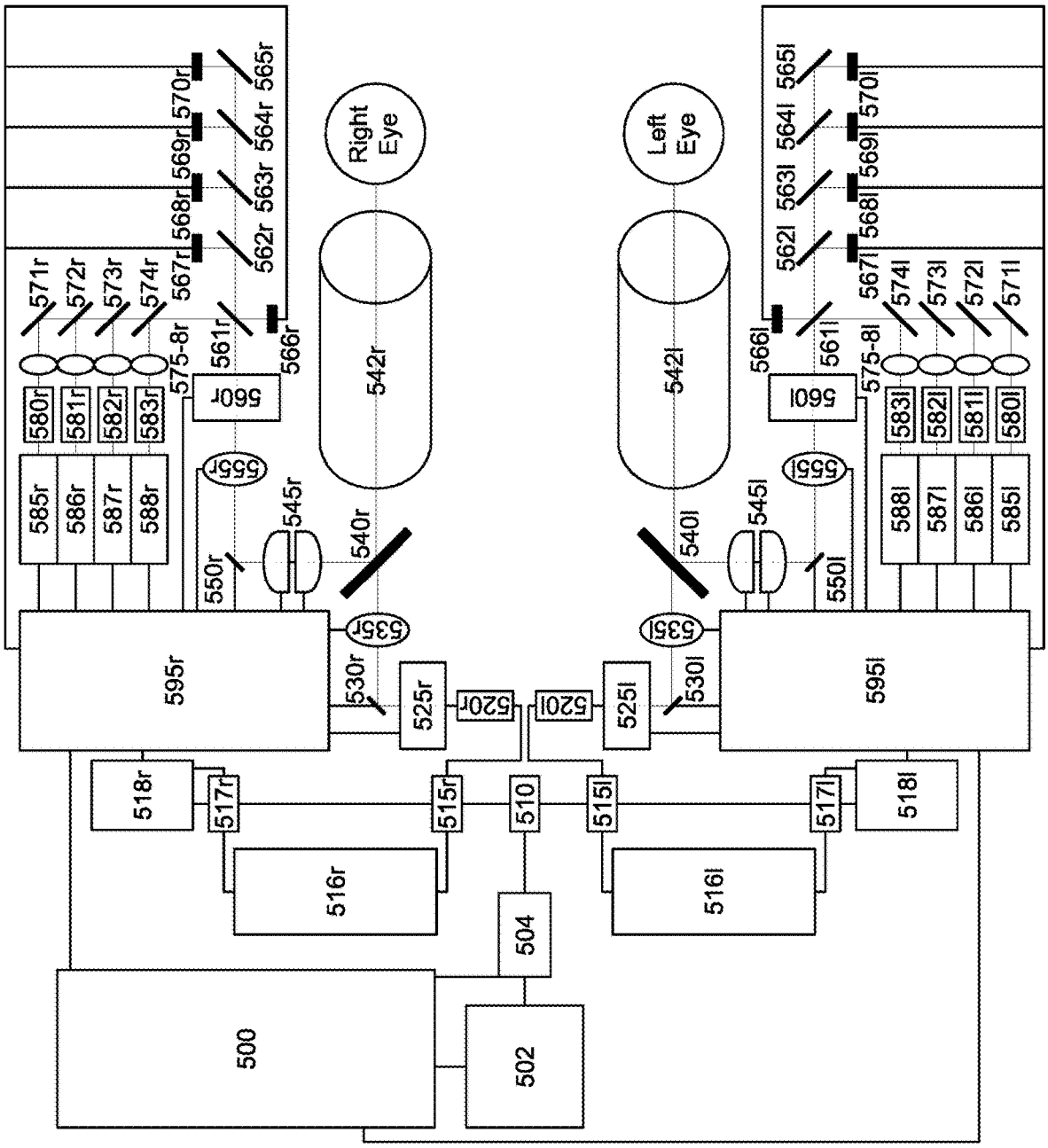

Please proceed along path indicated by the blue arrow on the map below.
You will arrive at device #1 where your eyes will be tested.
1
2
3
340
330
320
310
300

FIG. 10

FIG. 11


400
Encounter Registration
• Sign name or confirmation ID
• Present identification
• Indicate provider to be seen
• Verify address
• Verify insurance
• Make co- or pre-payments
• Consent to receive care
• Consent to privacy regulations
• Consent to internet upload
• Payment of other fees
410
Examination
• Verify identity
• Conduct history
• Undergo testing
• Review test results with provider
420
Check-out
• Schedule follow-up appointments
• Order future testing
• Order future therapies
• Enter billing information
• Allow patient to pay fees
• Receive results or other products


Right Eye
Left Eye
542r
542l
540r
540l
545r
545l
550r
550l
555r
555l
560r
560l
561r
561l
562r
562l
563r
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567l
568r
568l
569r
569l
570r
570l
571r
571l
572r
572l
573r
573l
574r
574l
575-8r
575-8l
580r
580l
581r
581l
582r
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583r
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595l
530r
530l
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515l
510
516r
516l
504
500
502

FIG. 12

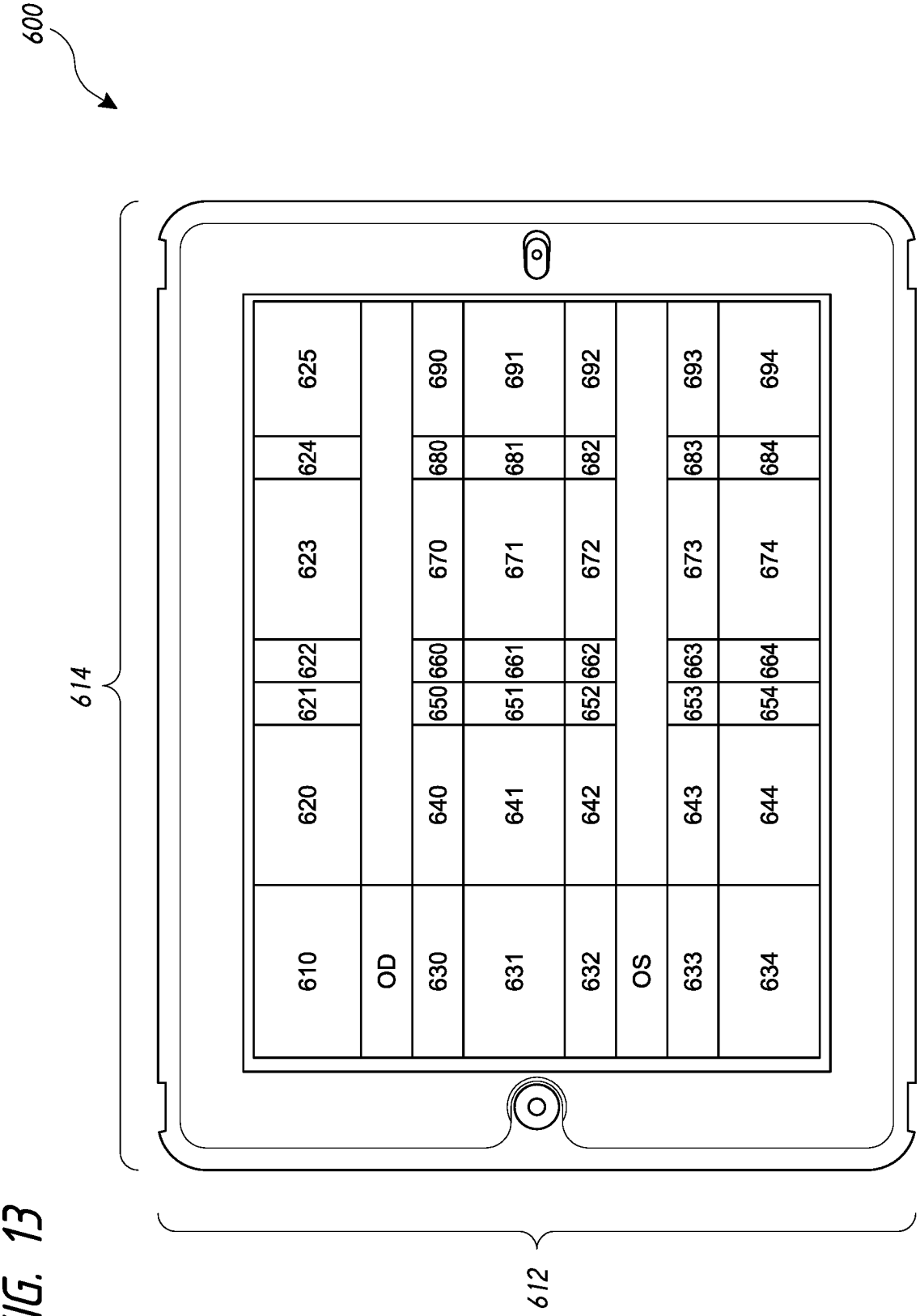

600
614
612
610
620
621
622
623
624
625
OD
630
640
650
660
670
680
690
631
641
651
661
671
681
691
632
642
652
662
672
682
692
OS
633
643
653
663
673
683
693
634
644
654
664
674
684
694

FIG. 13

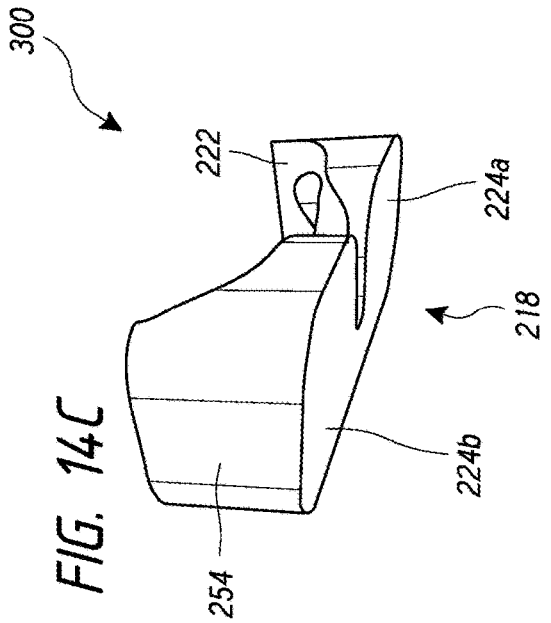


FIG. 14C

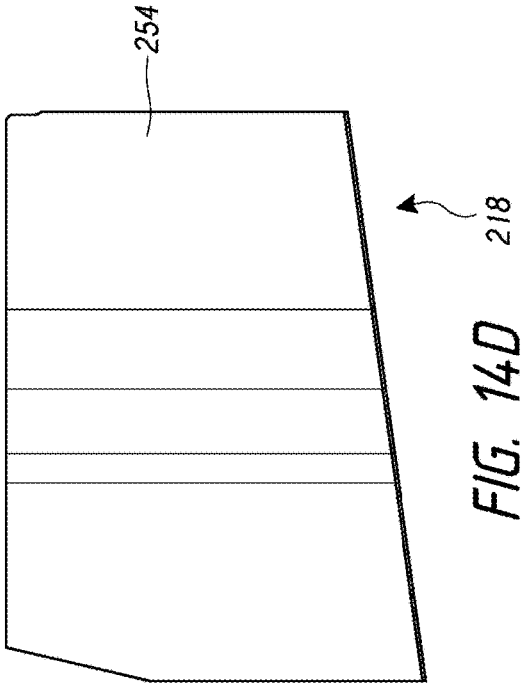


FIG. 14D

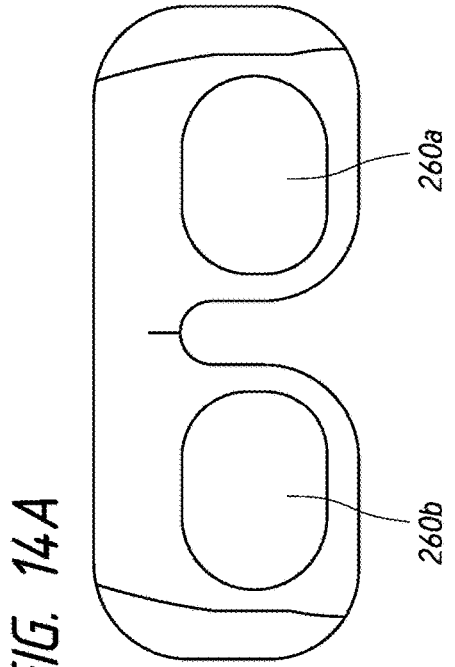


FIG. 14A

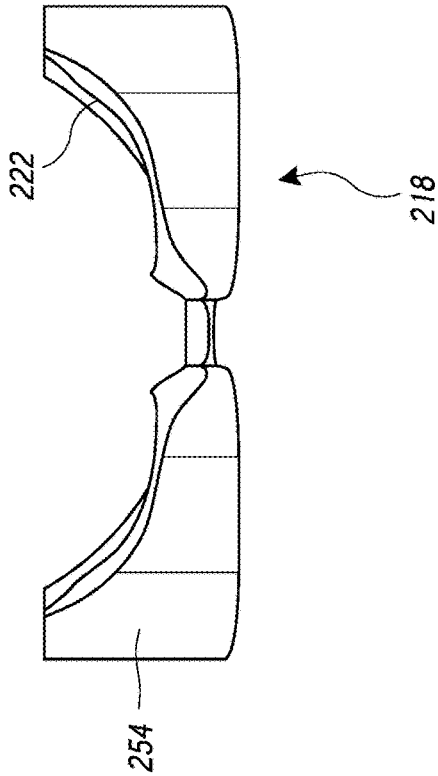


FIG. 14B

Offset angle Δ reduces back-reflection into beam steering mirror

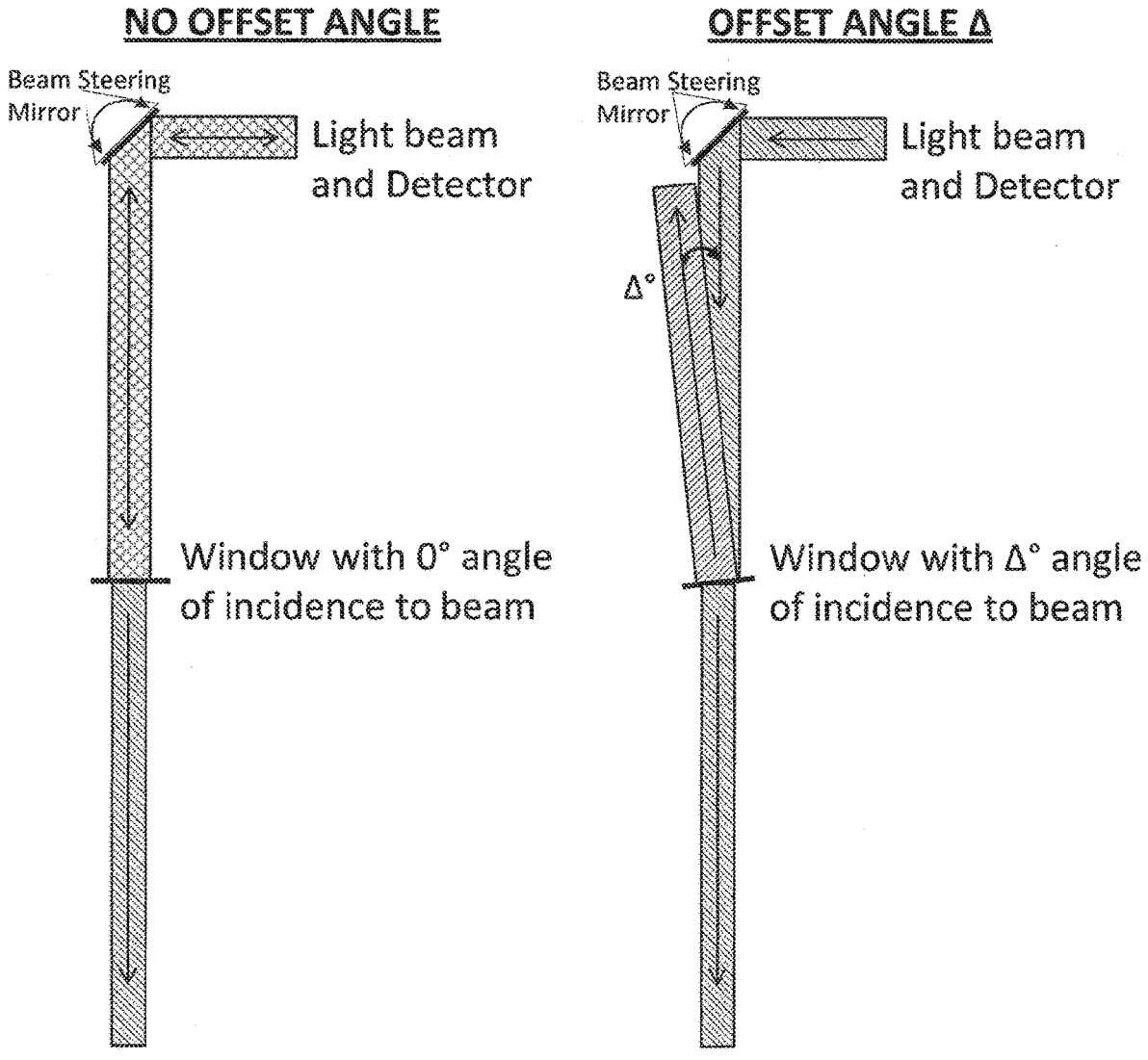


FIG. 15A

FIG. 15B

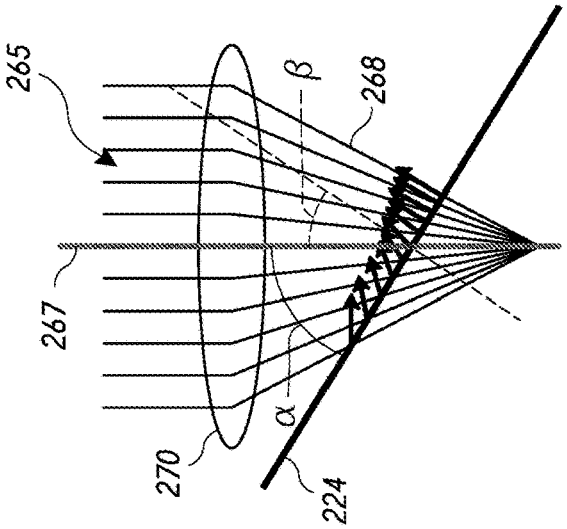


FIG. 15E

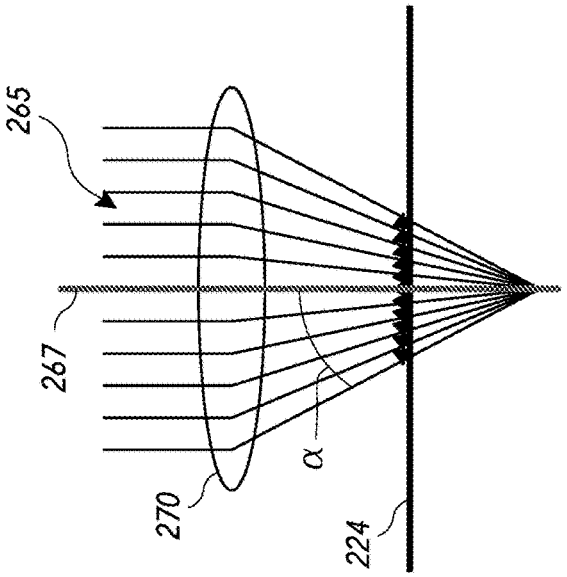


FIG. 15D

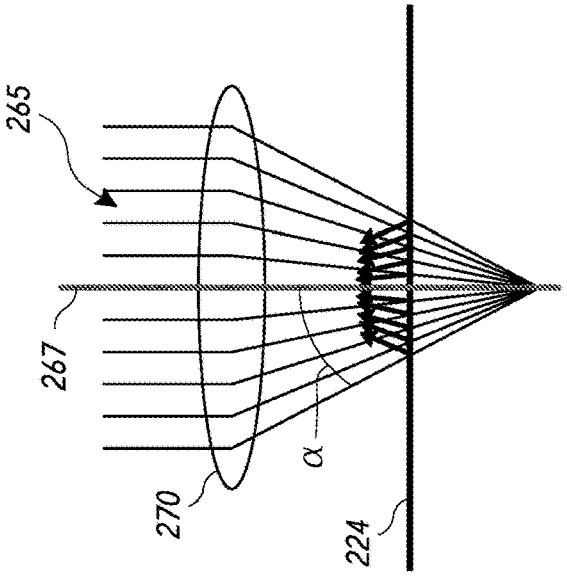


FIG. 15C

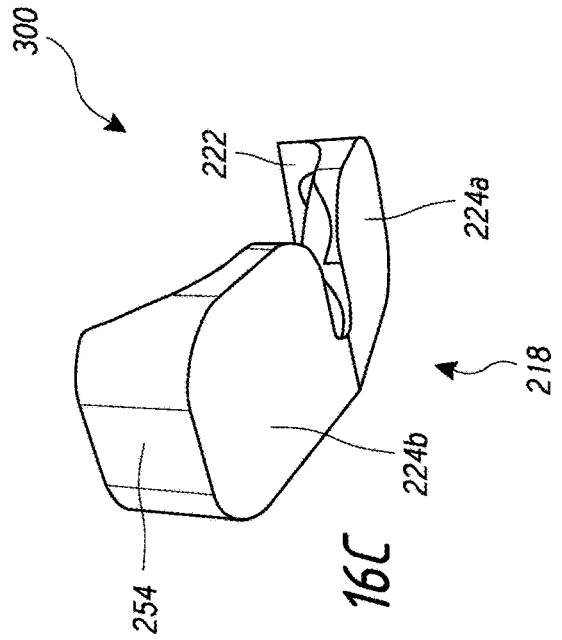


FIG. 16C

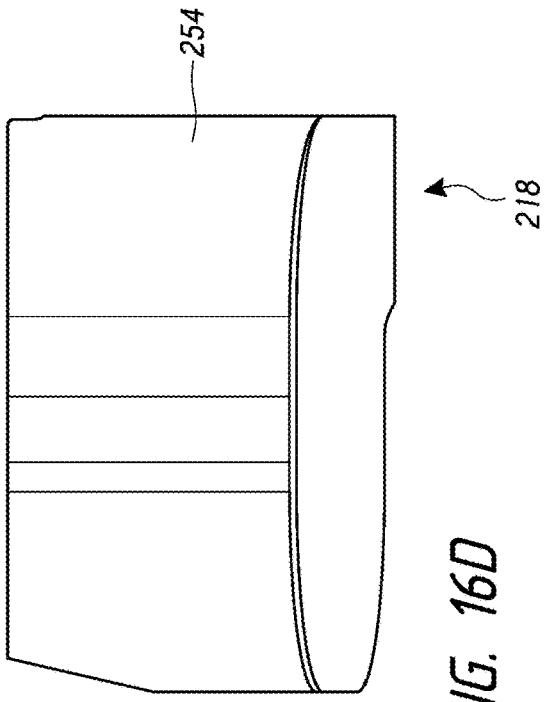


FIG. 16D

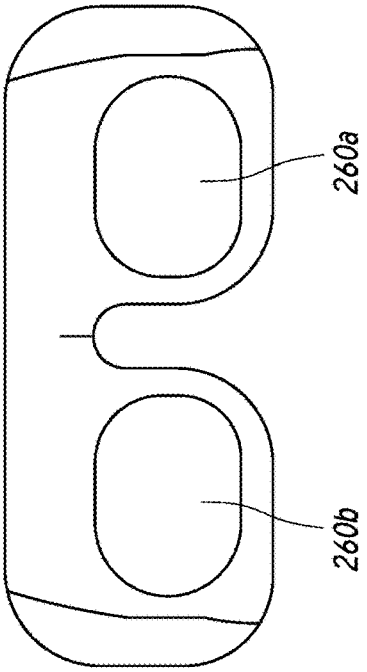


FIG. 16A

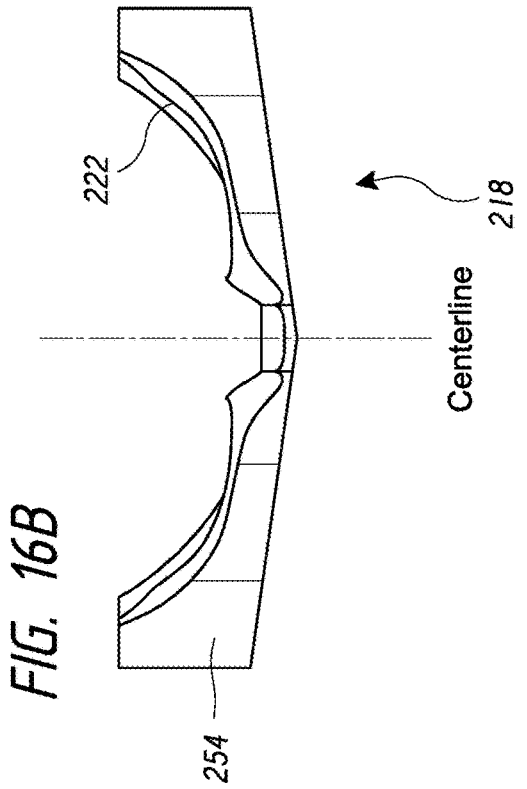


FIG. 16B

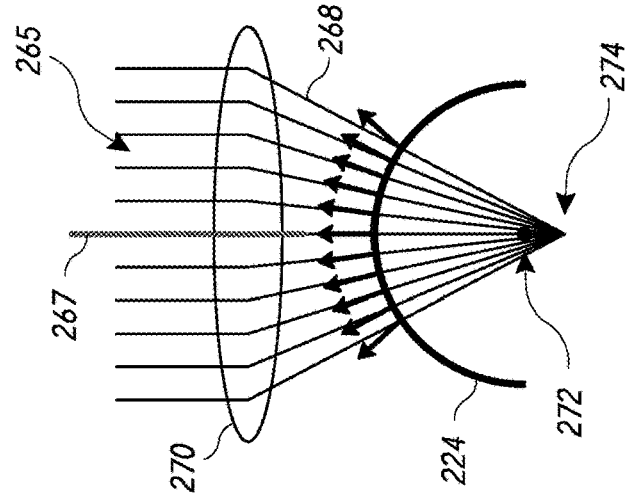


FIG. 17C

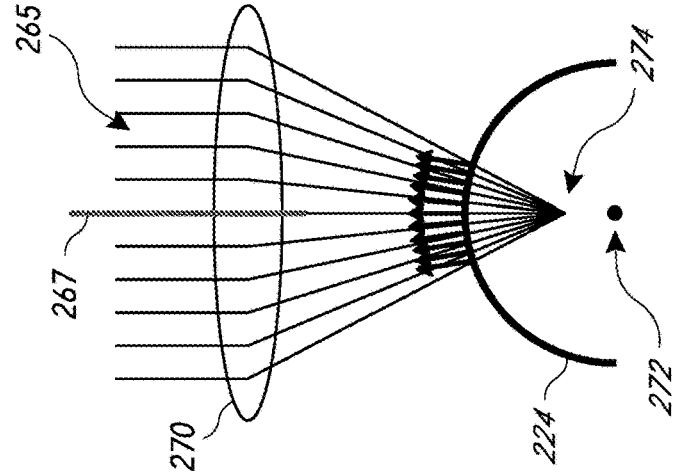


FIG. 17B

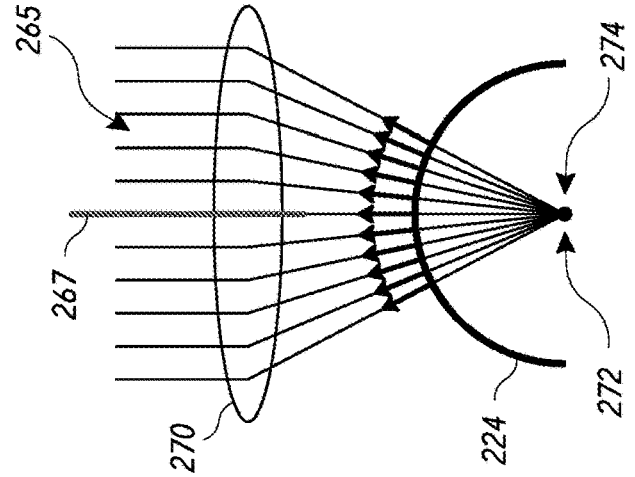


FIG. 17A

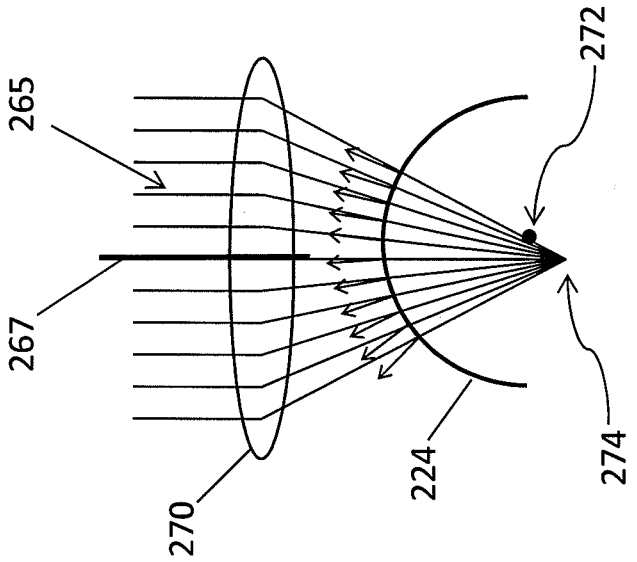


FIG. 17E

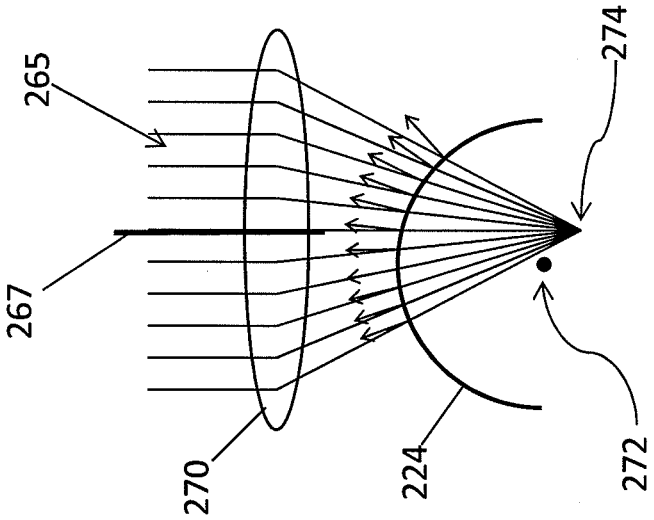


FIG. 17D

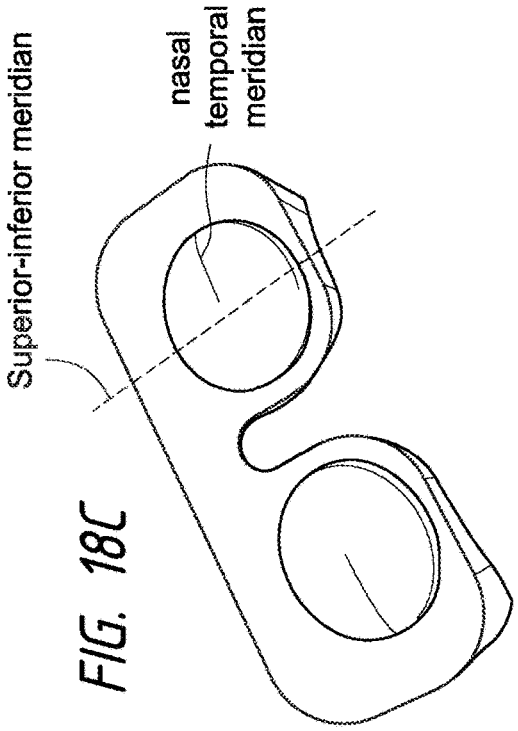


FIG. 18C

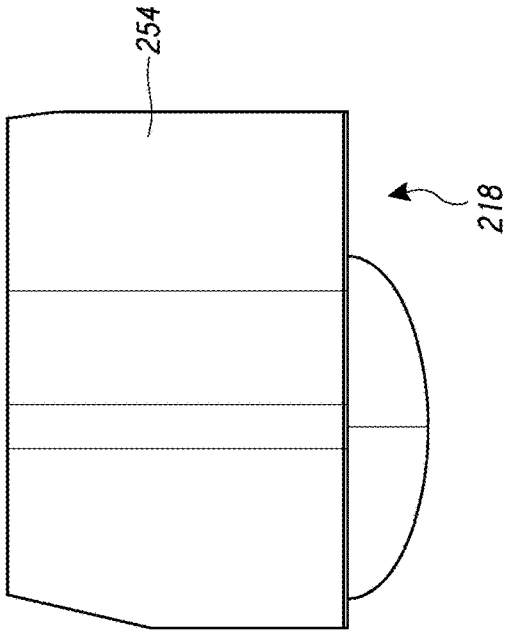


FIG. 18D

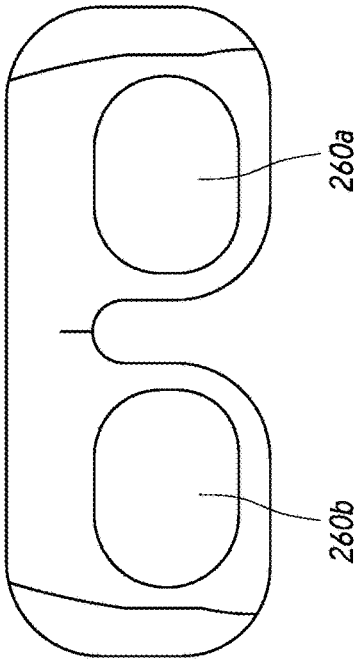


FIG. 18A

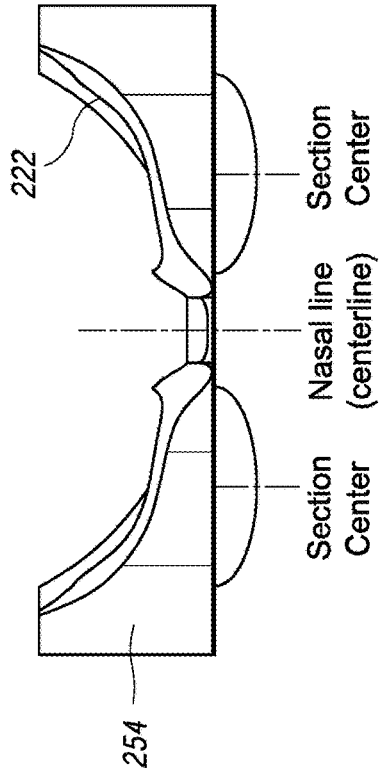


FIG. 18B

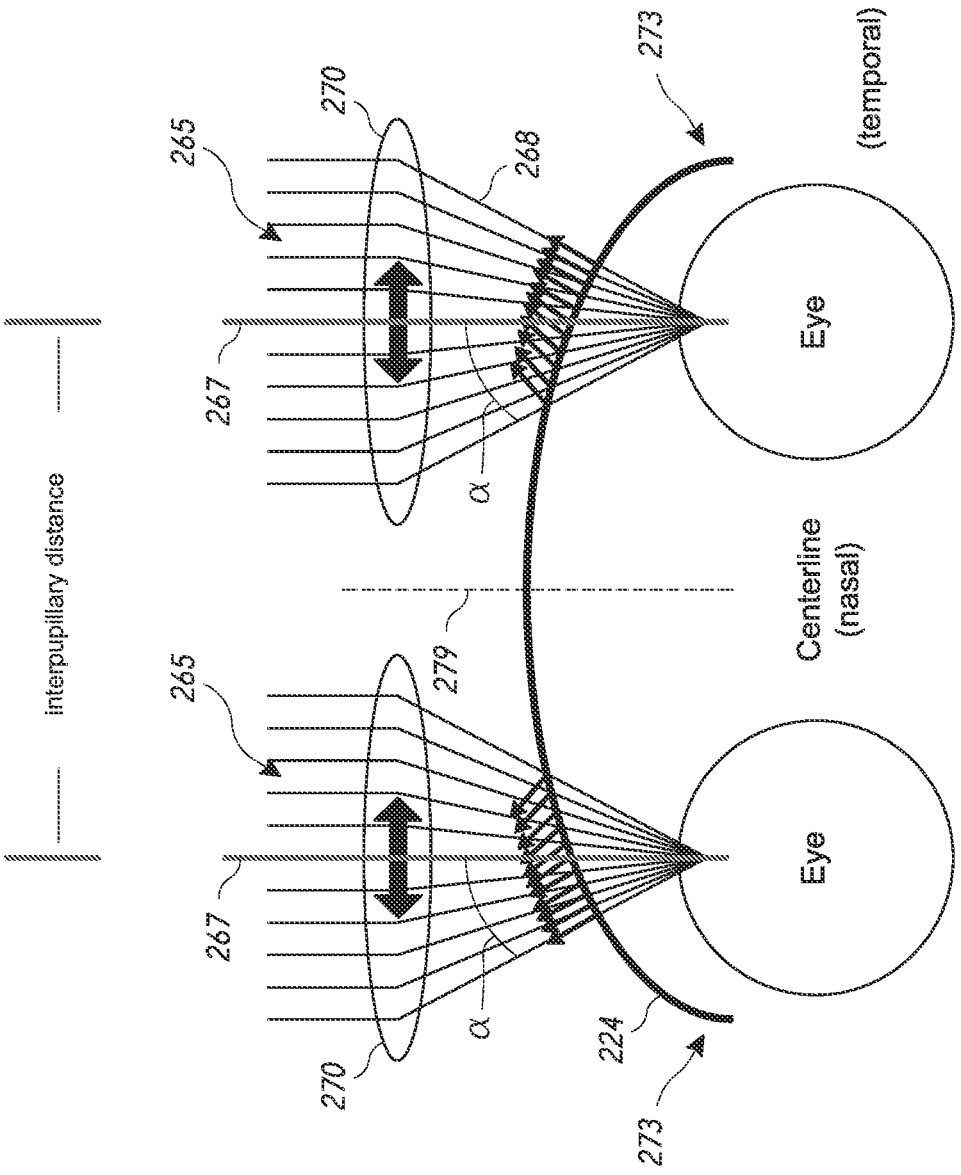

interpupillary distance
265
267
270
268
273
(temporal)
Eye
α
Centerline
(nasal)
279
265
267
270
α
224
273
Eye

FIG. 19

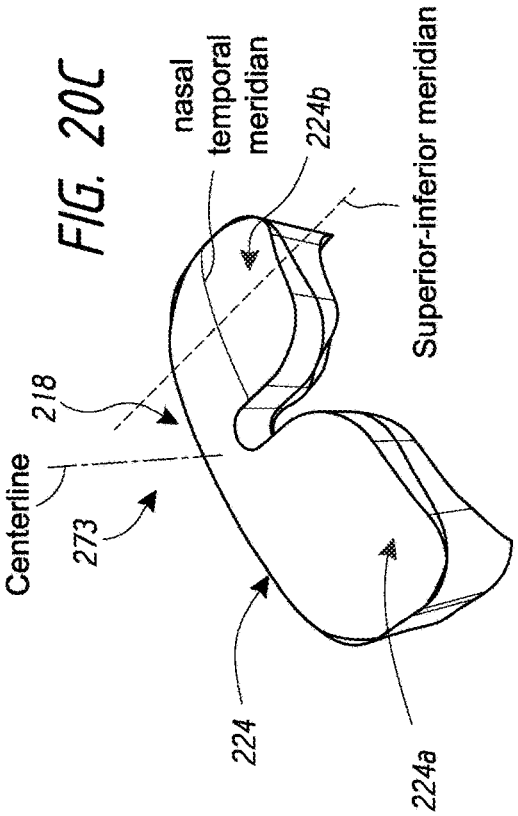


FIG. 20C

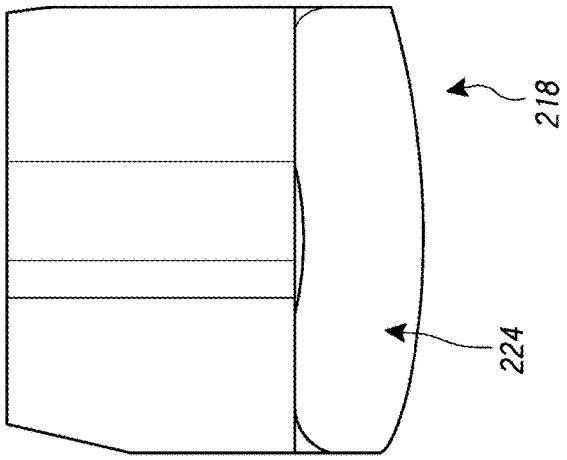


FIG. 20D

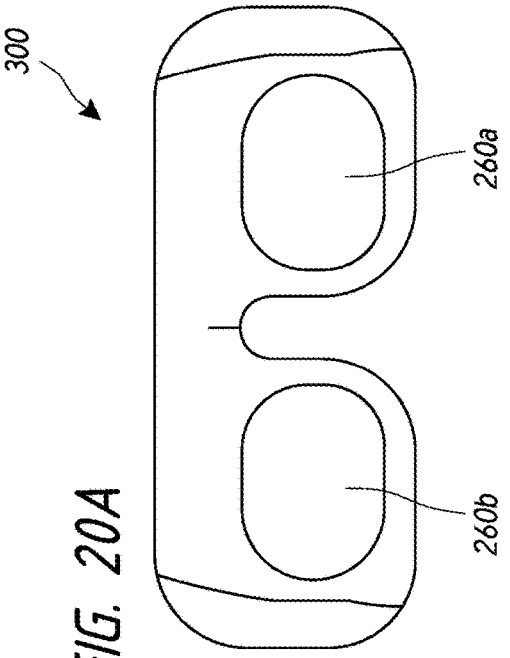


FIG. 20A

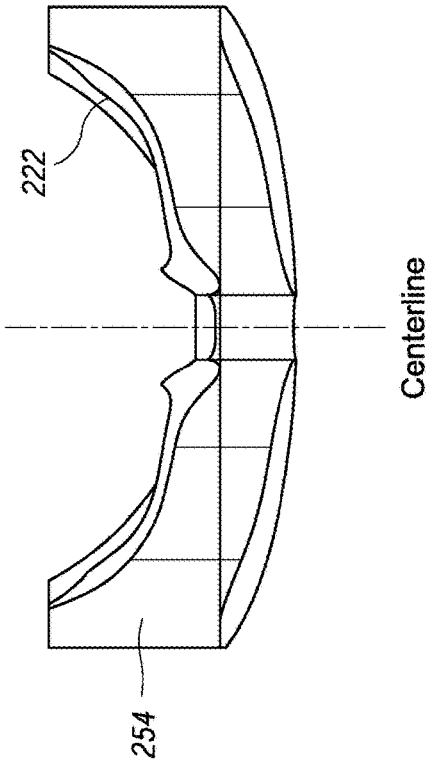


FIG. 20B

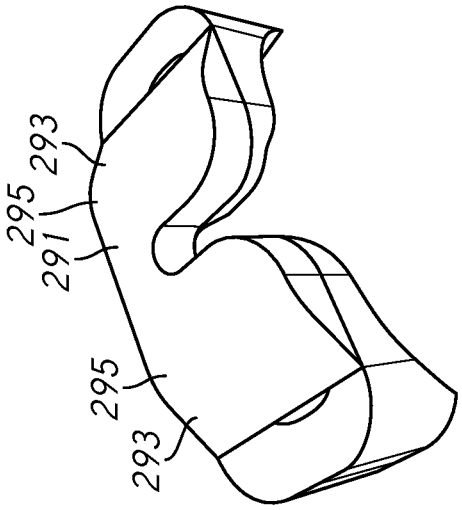


FIG. 21B

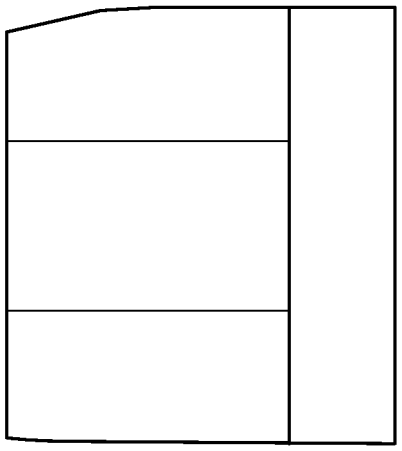


FIG. 21D

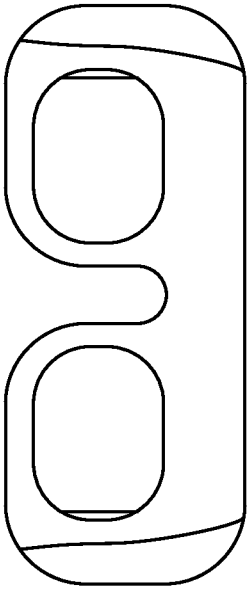


FIG. 21A

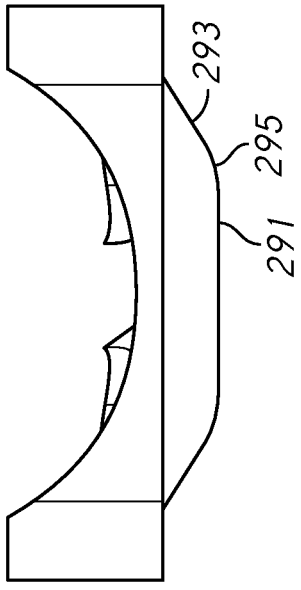


FIG. 21C

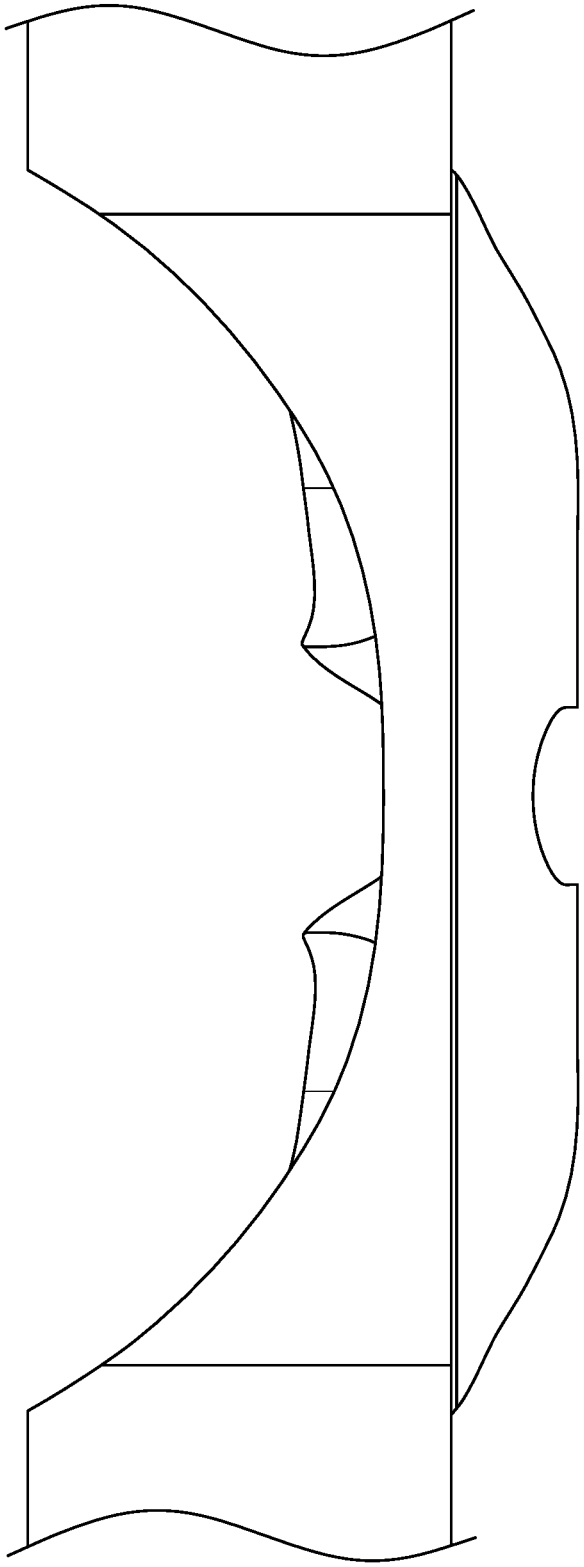


FIG. 22

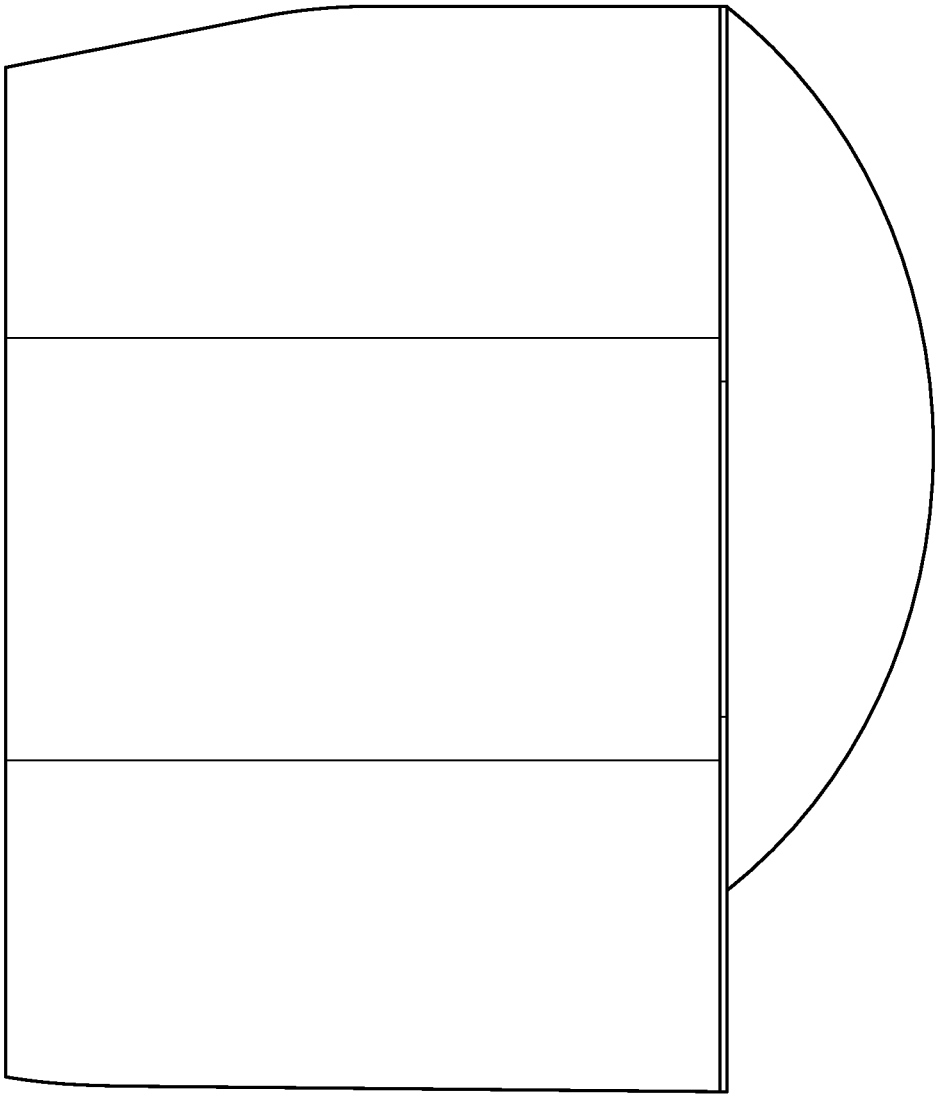


FIG. 23

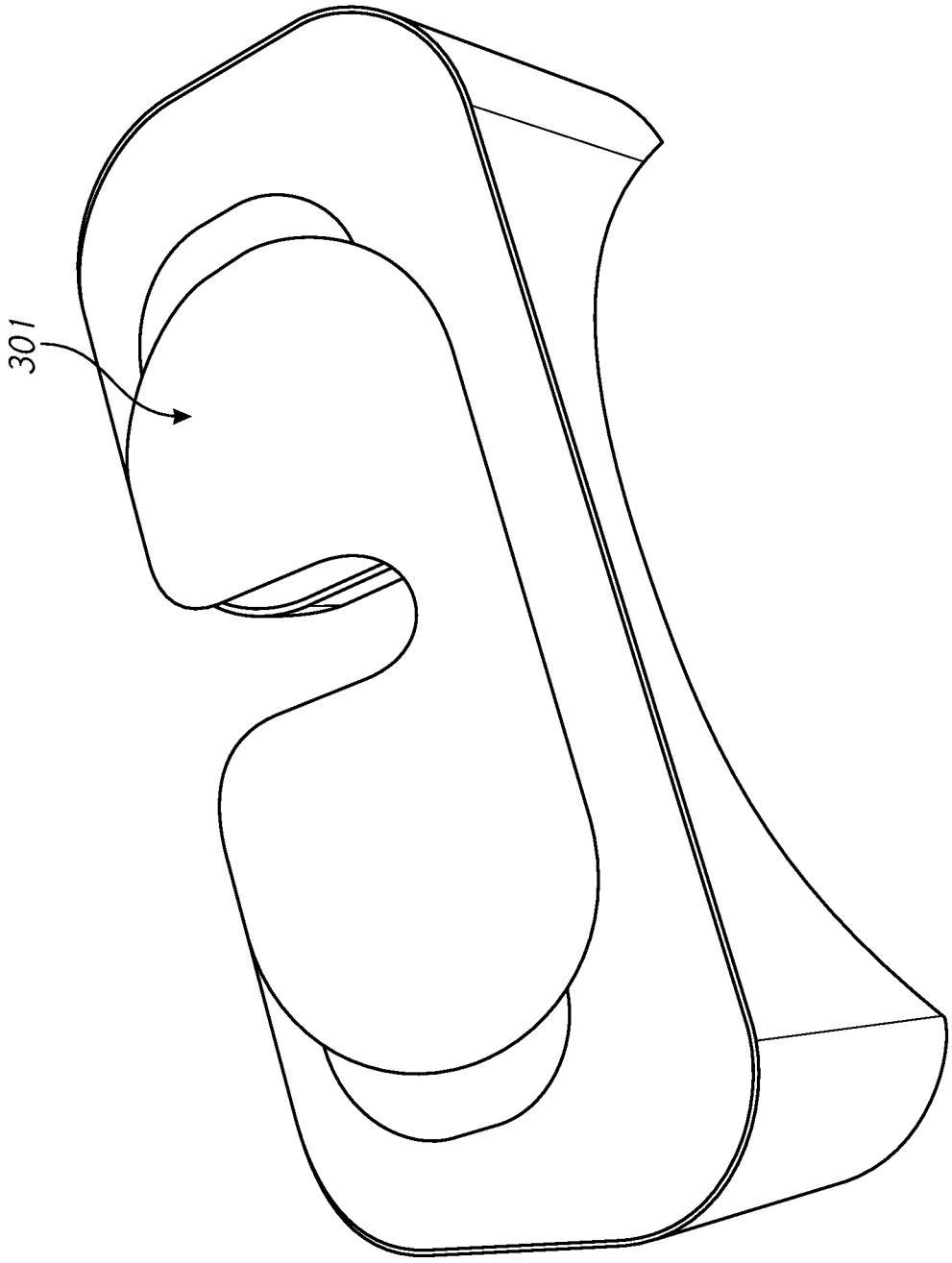


FIG. 24

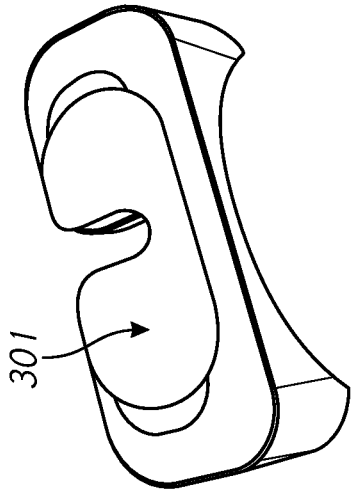


FIG. 25B

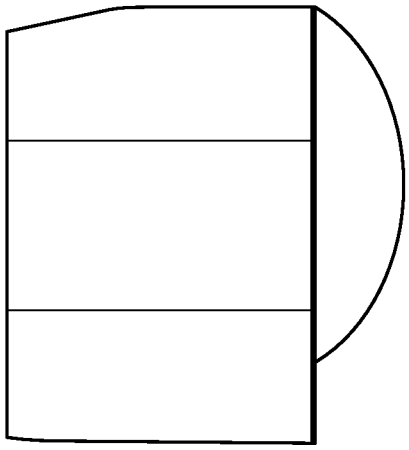


FIG. 25D

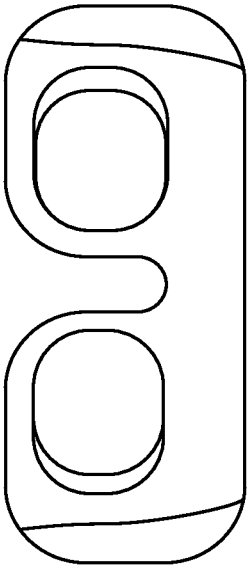


FIG. 25A

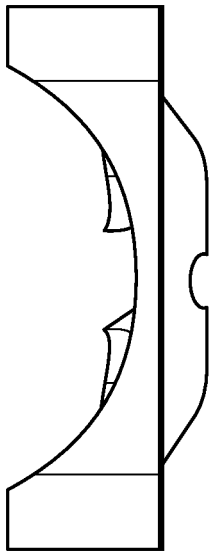


FIG. 25C

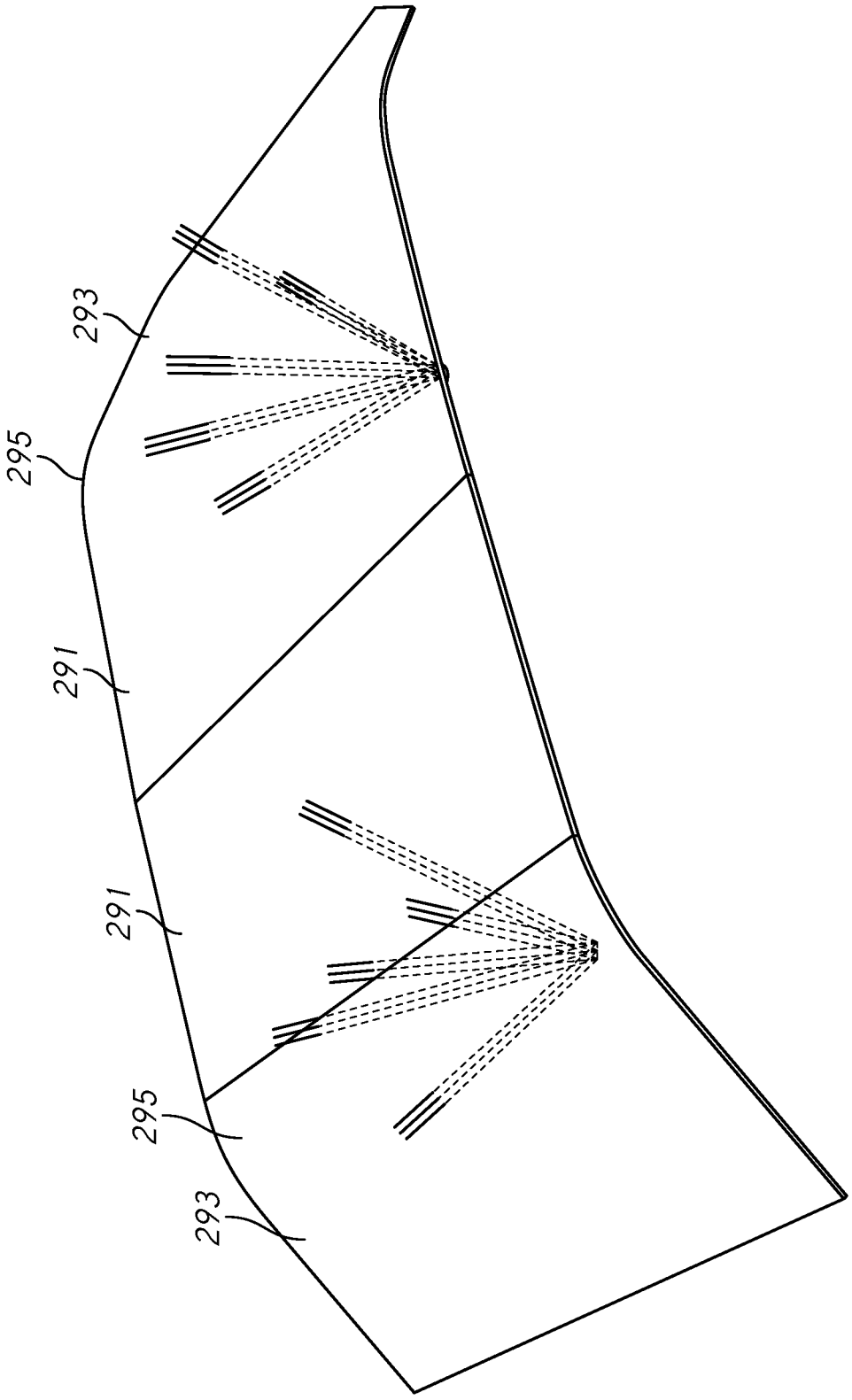


FIG. 26

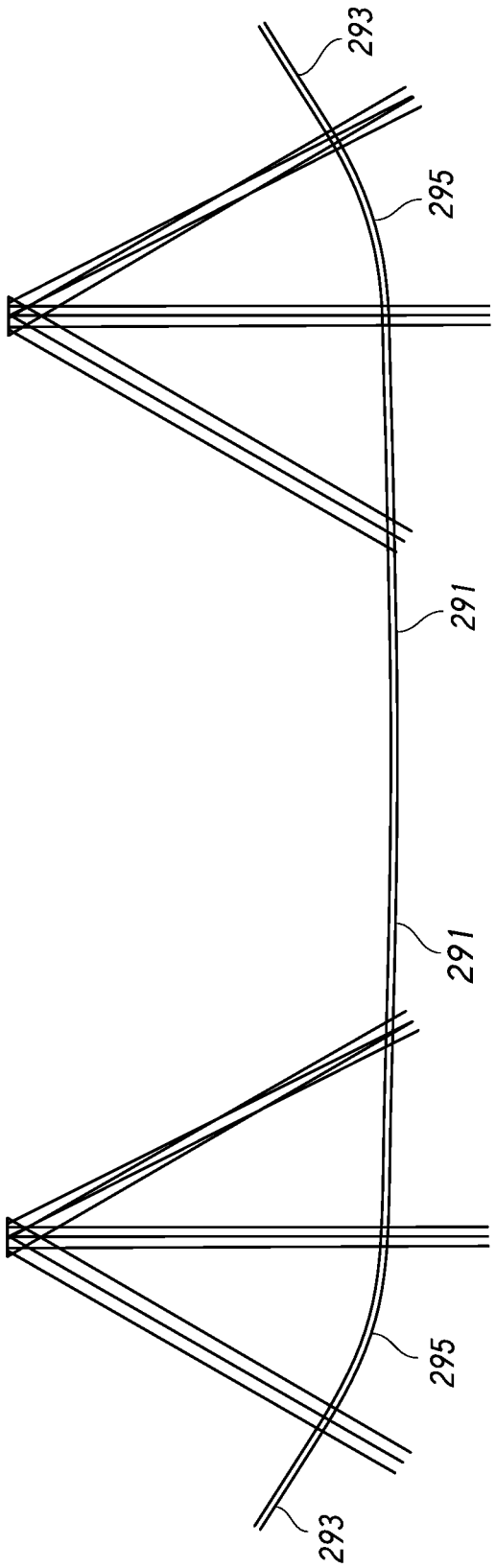


FIG. 27

FIG. 28A

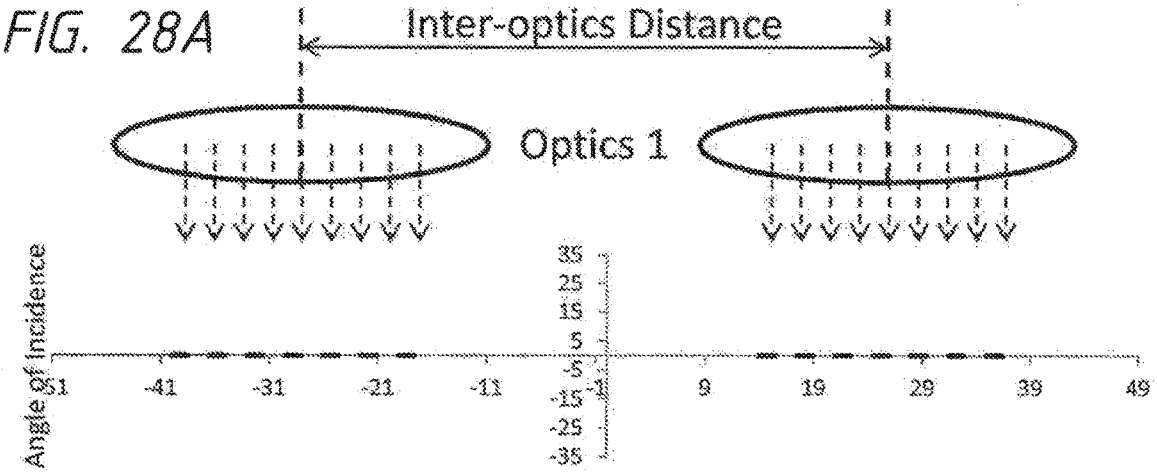
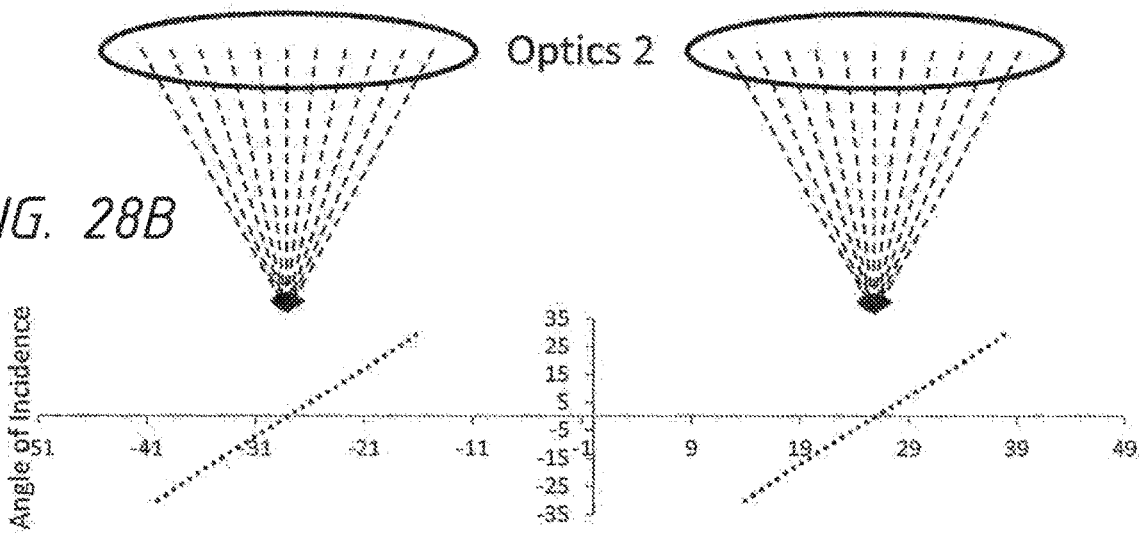


FIG. 28B



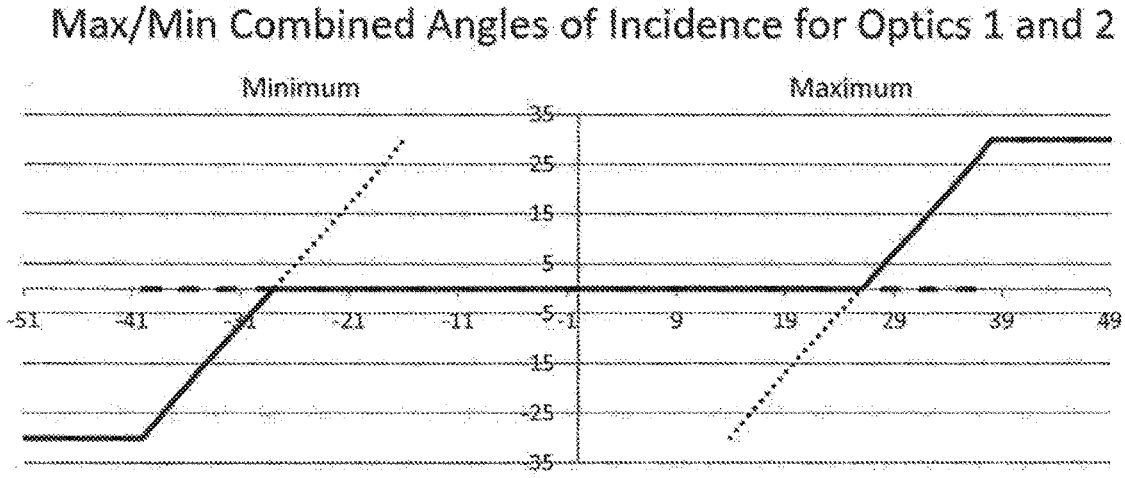


FIG. 28C

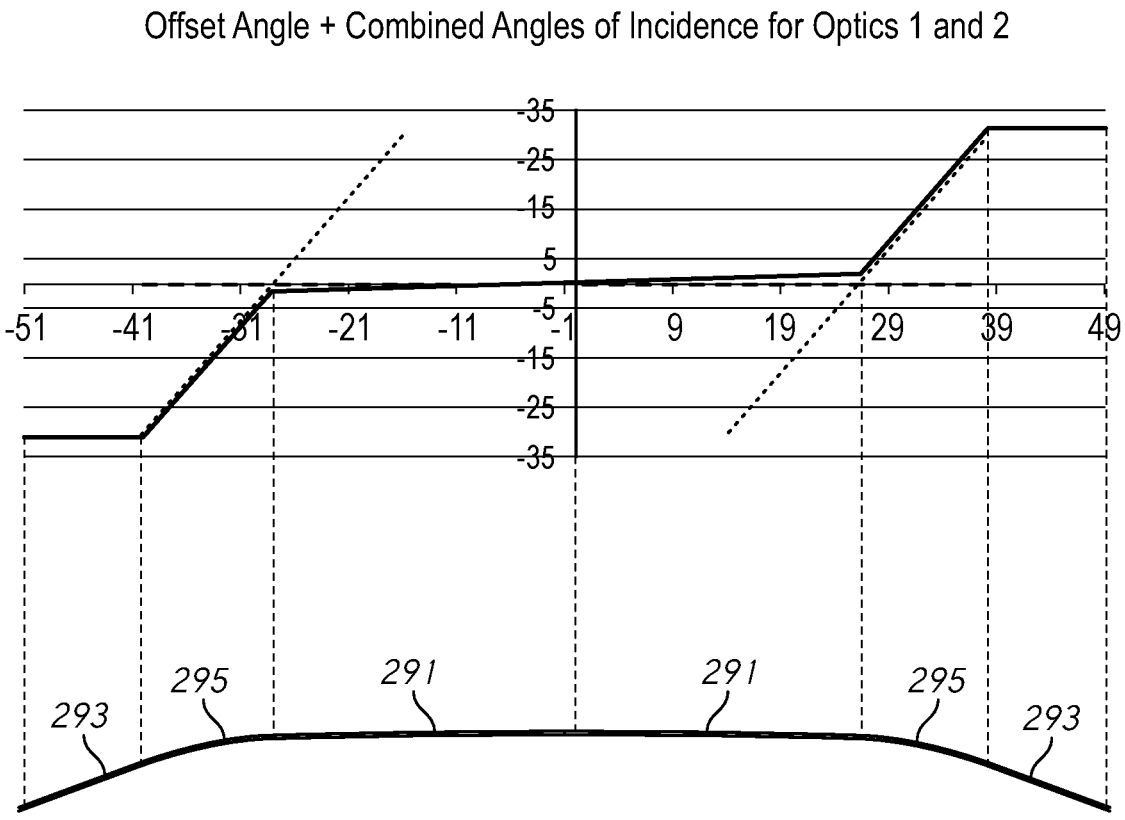

Offset Angle + Combined Angles of Incidence for Optics 1 and 2
-35
-25
-15
-5
5
15
25
35
-51
-41
-31
-21
-11
-1
9
19
29
39
49
293
295
291
291
295
293
Sample final mask window contour based on optical parameters

FIG. 28D

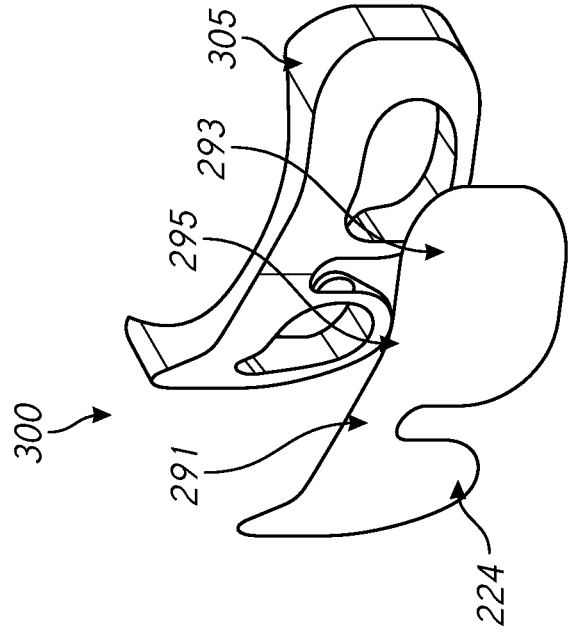


FIG. 29B

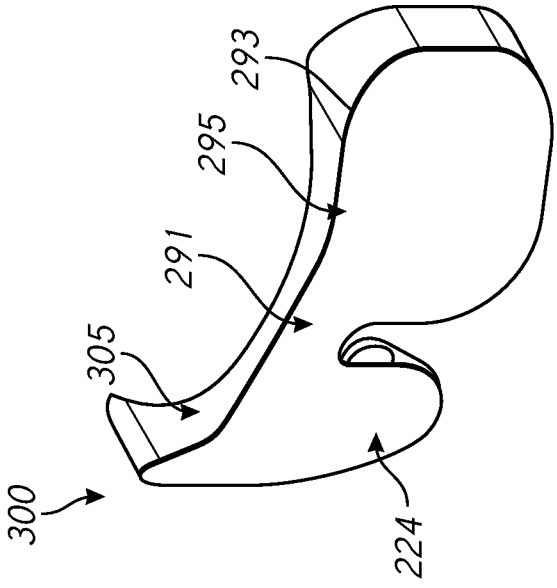


FIG. 29A

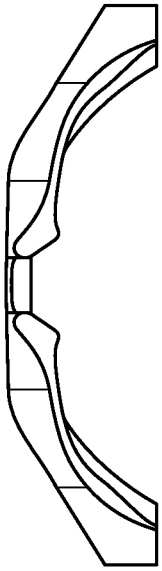


FIG. 29C

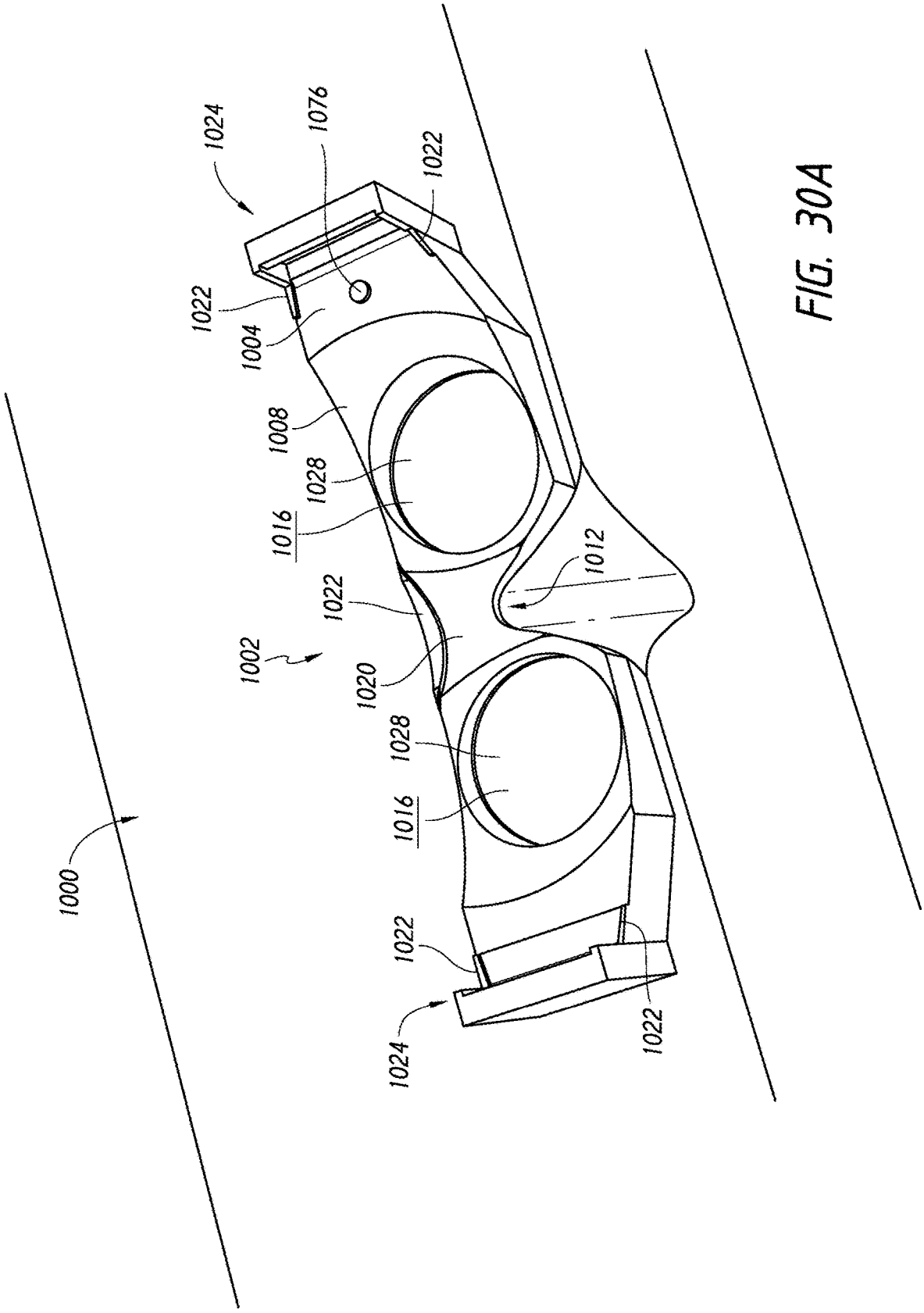


FIG. 30A

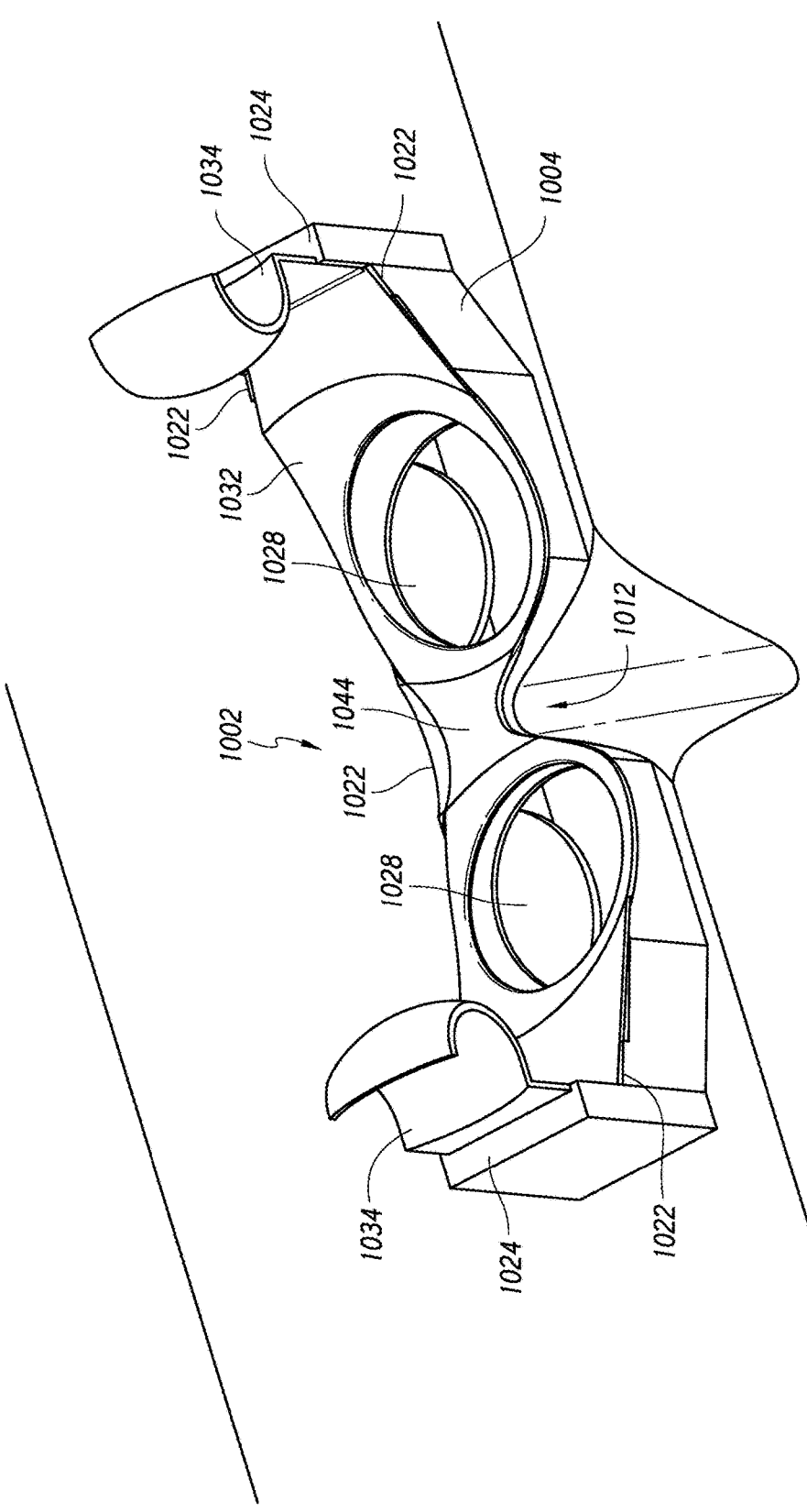

1034
1024
1022
1004
1022
1032
1028
1012
1044
1002
1022
1028
1034
1024
1022

FIG. 30B

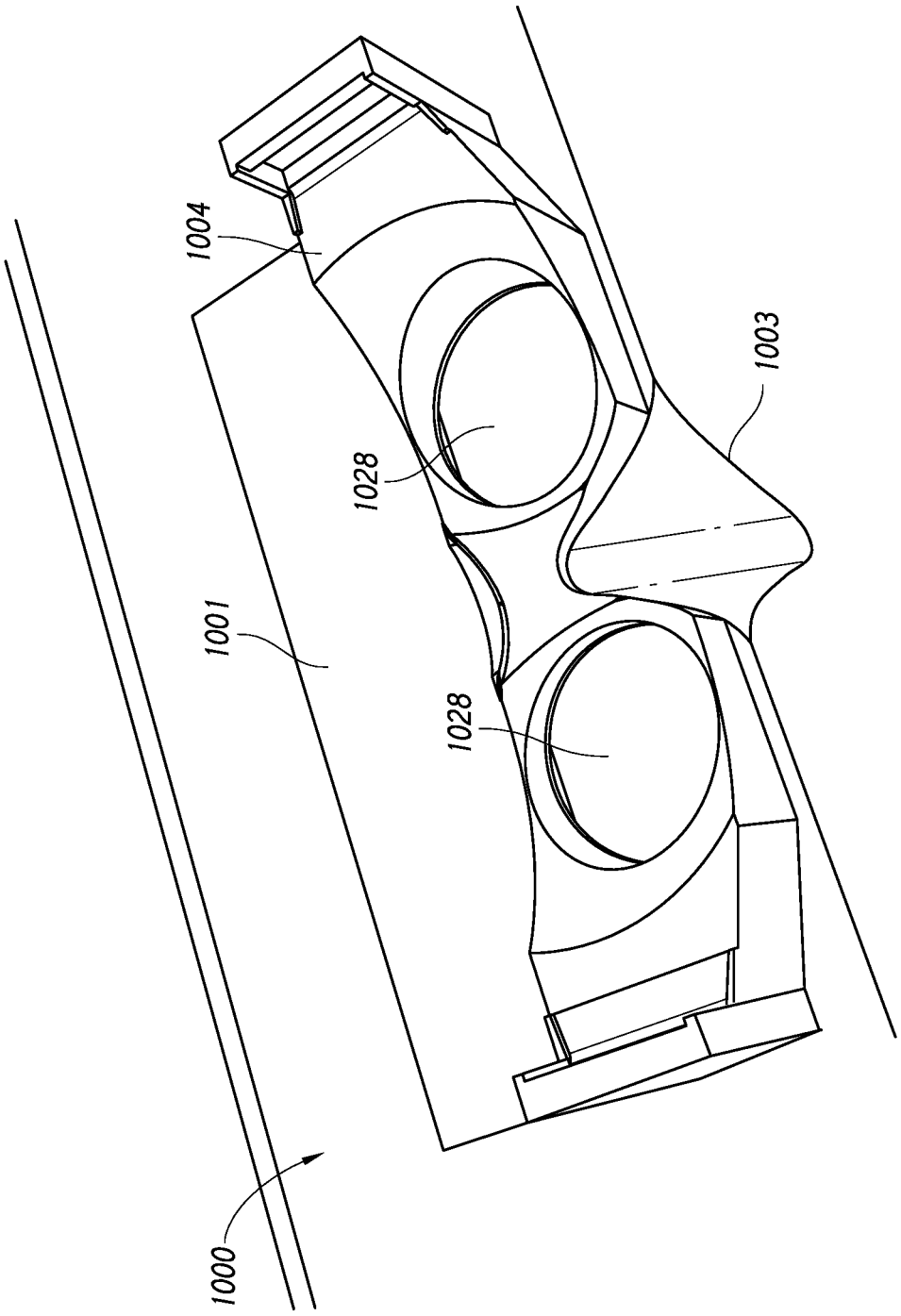


FIG. 30C

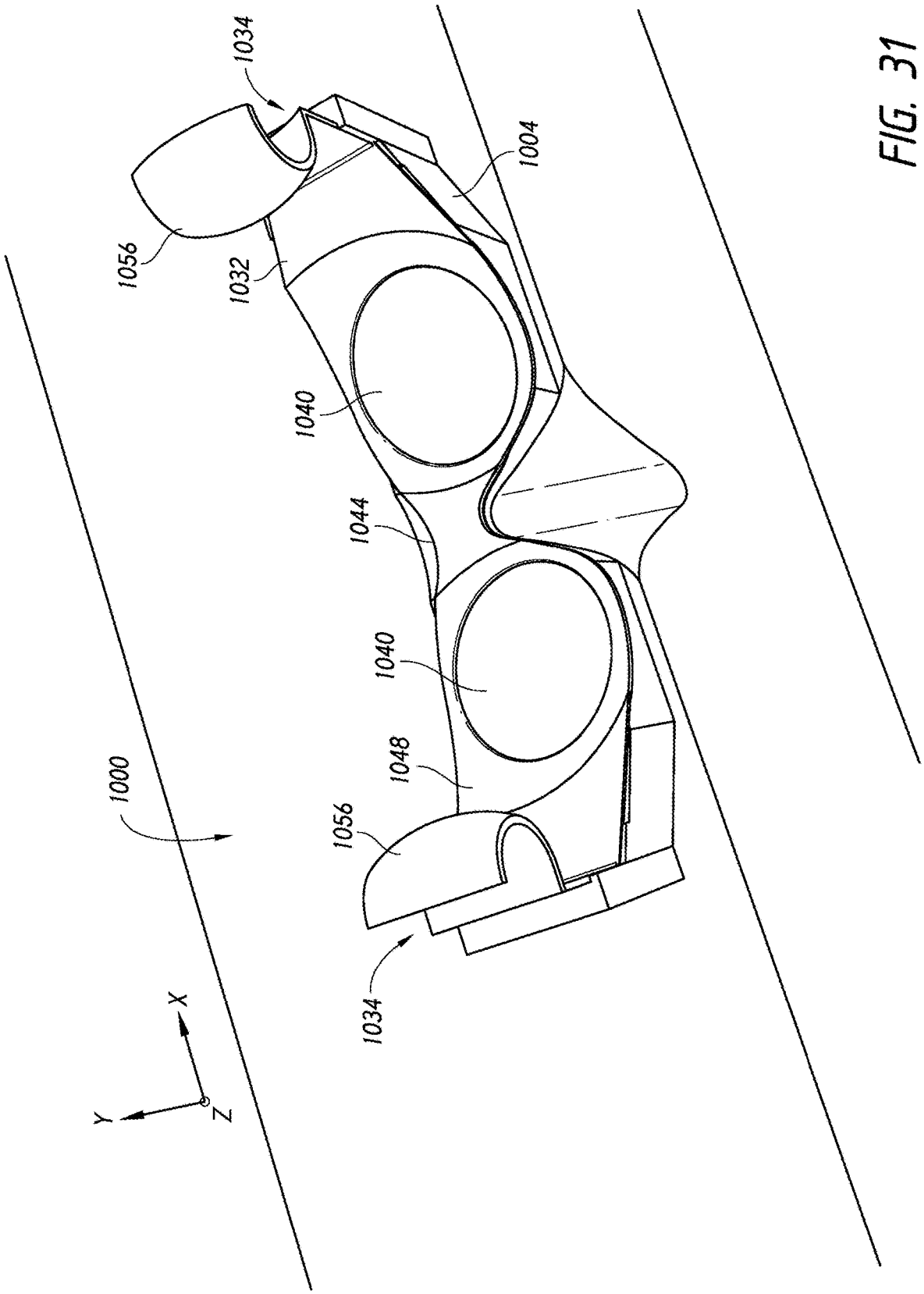


FIG. 31

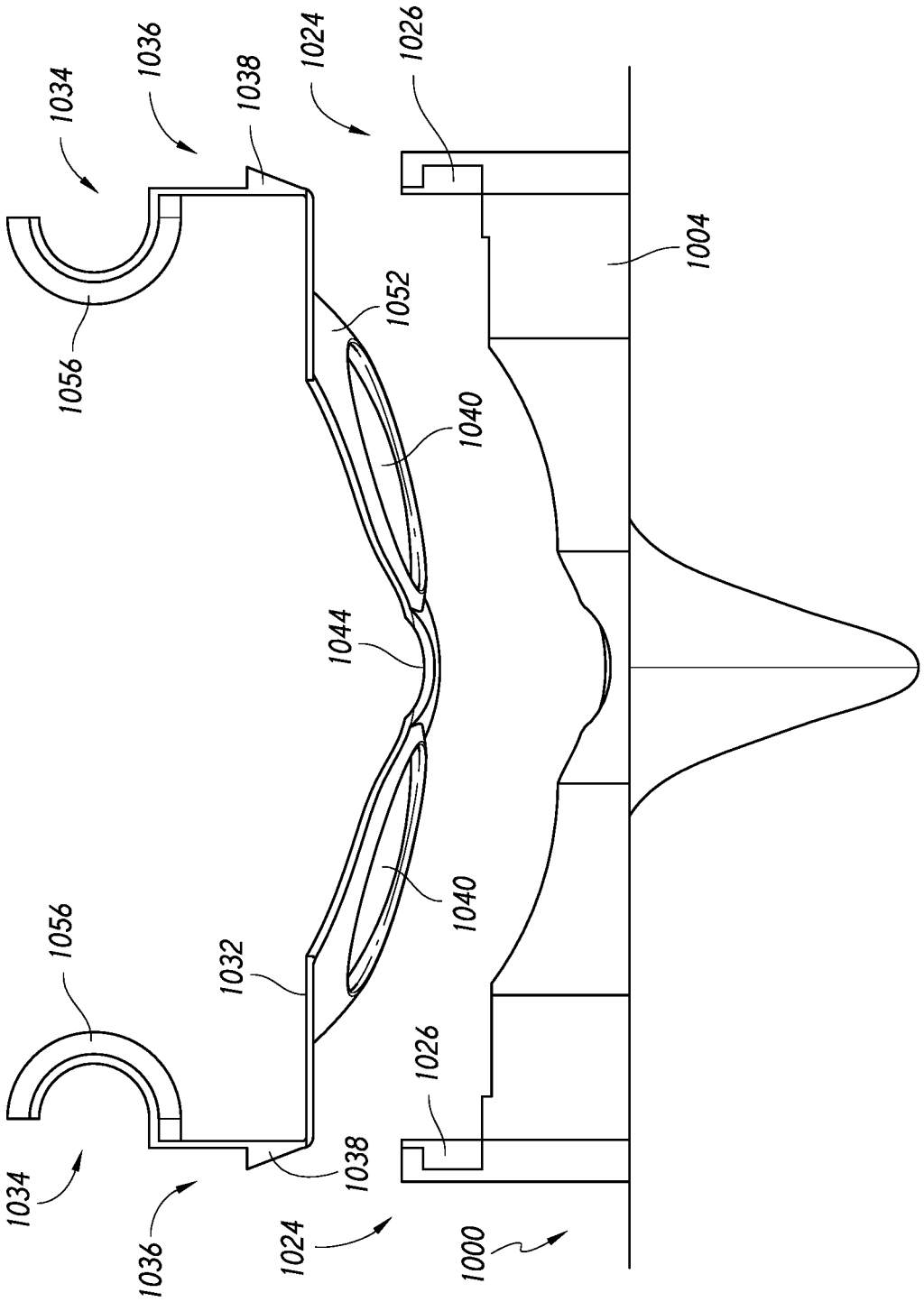


FIG. 32A

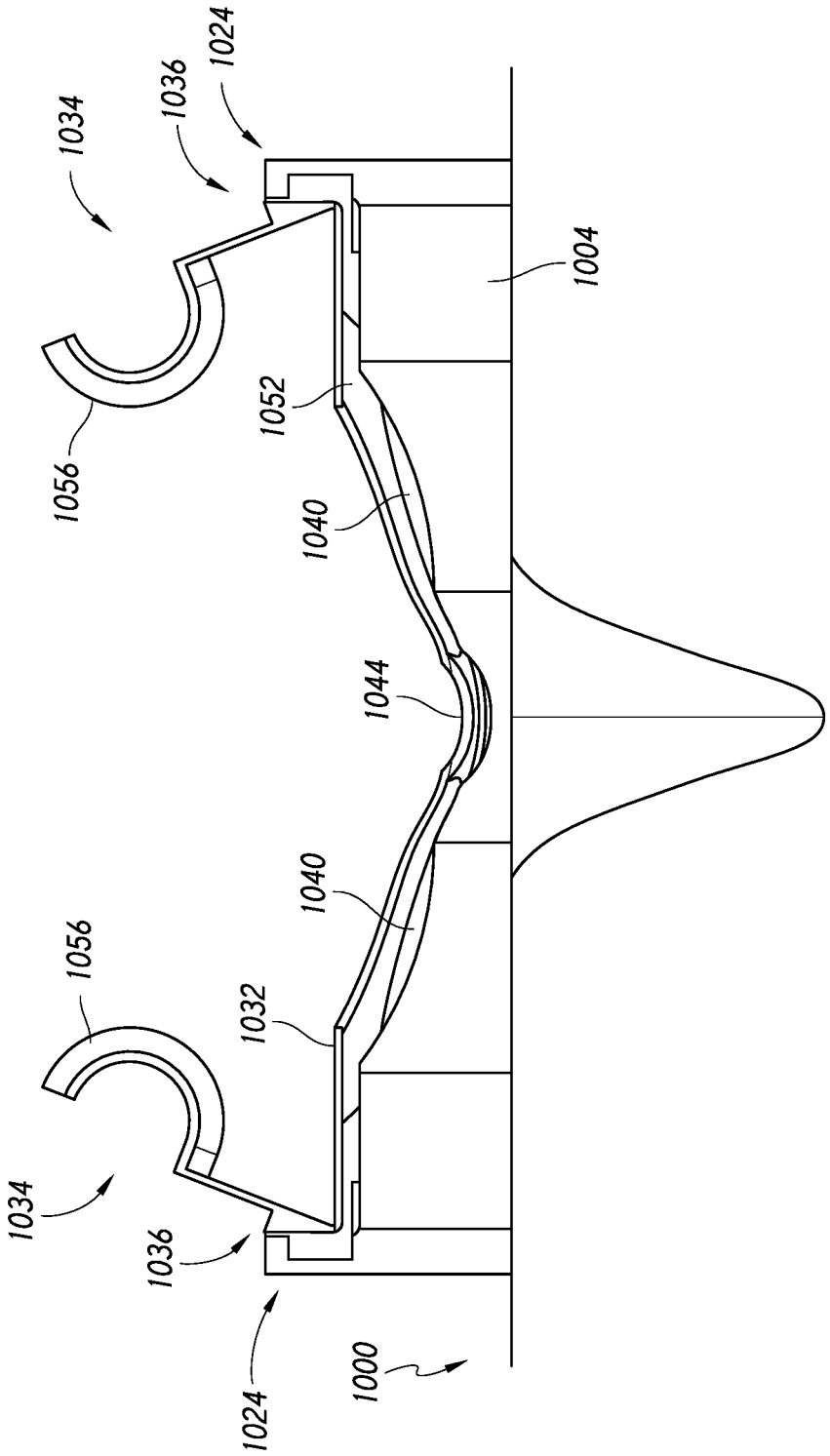

1024
1036
1034
1004
1052
1056
1040
1044
1040
1032
1056
1034
1036
1024
1000

FIG. 32B

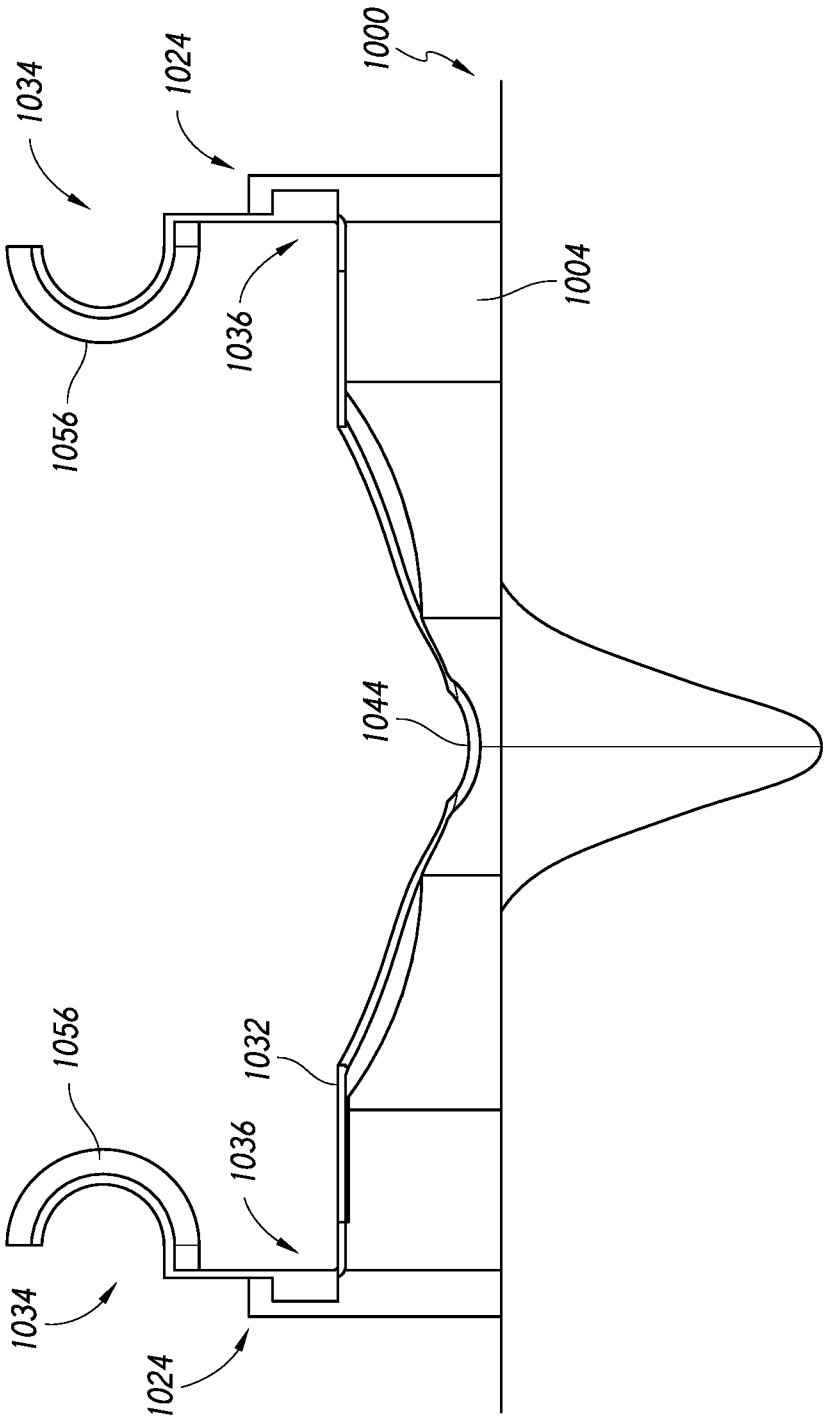


FIG. 32C

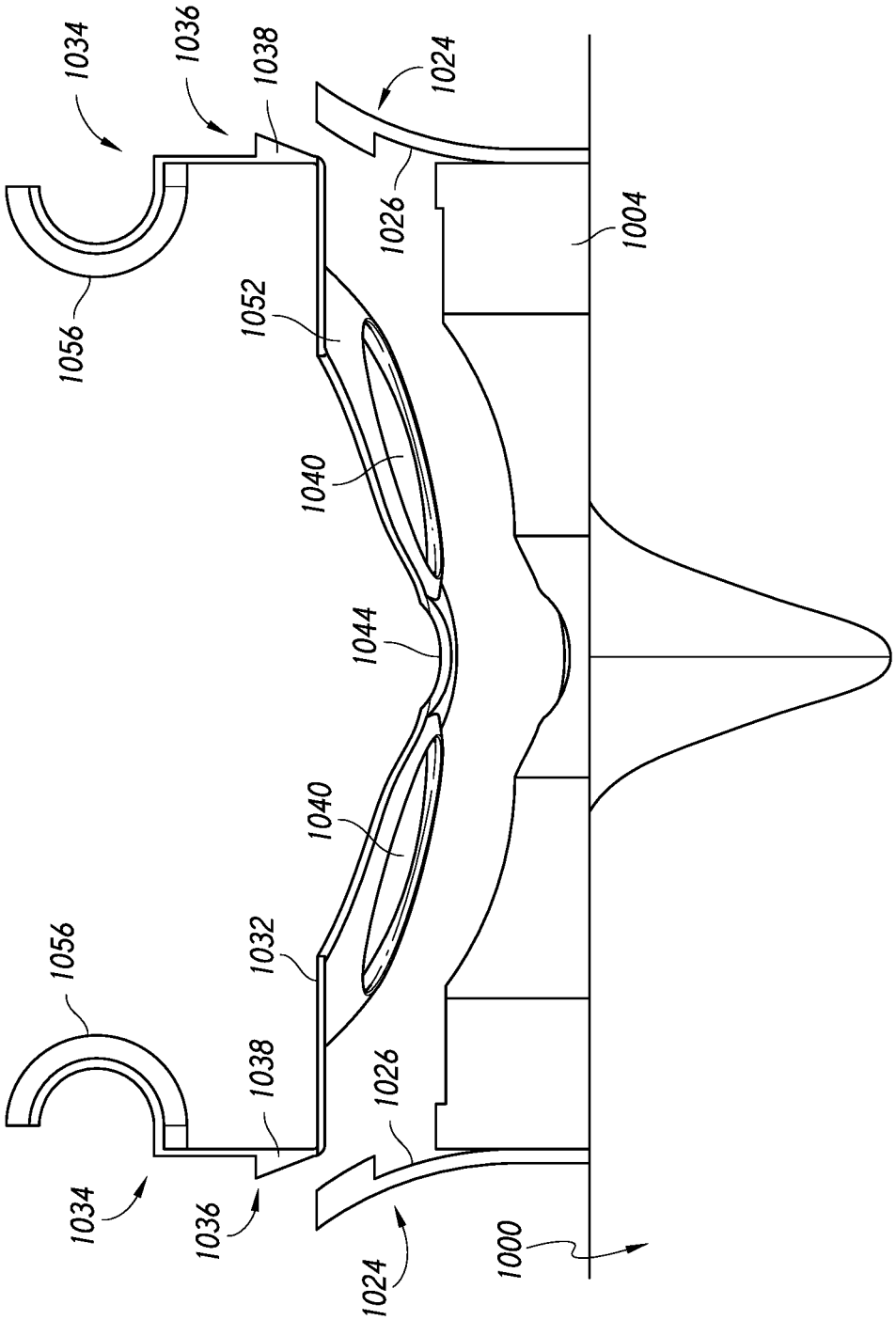

1034
1036
1038
1024
1026
1004
1056
1052
1040
1044
1040
1032
1056
1038
1026
1034
1036
1024
1000

FIG. 33A

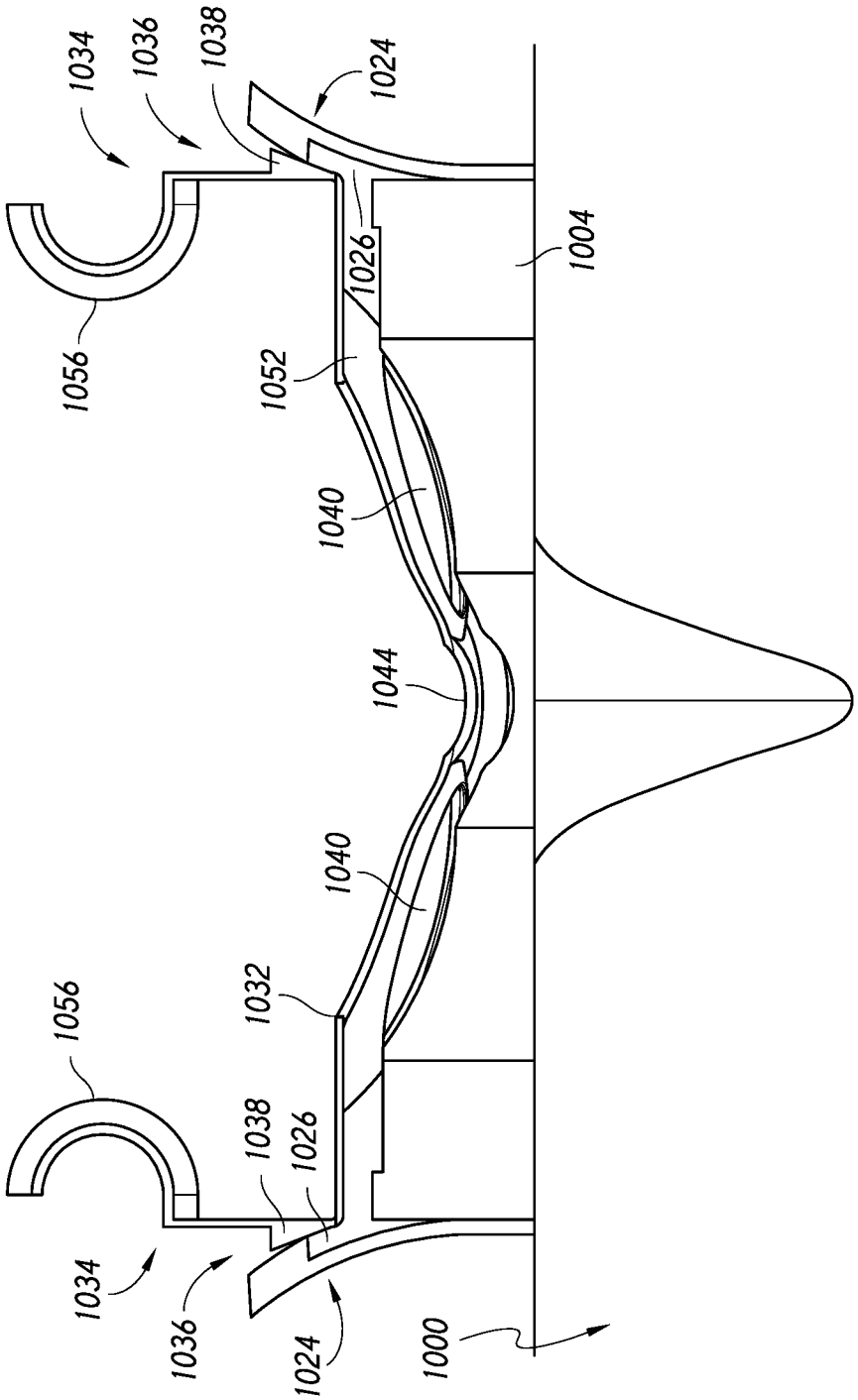

1034
1036
1038
1024
1026
1004
1056
1052
1040
1044
1040
1032
1056
1038
1026
1034
1036
1024
1000

FIG. 33B

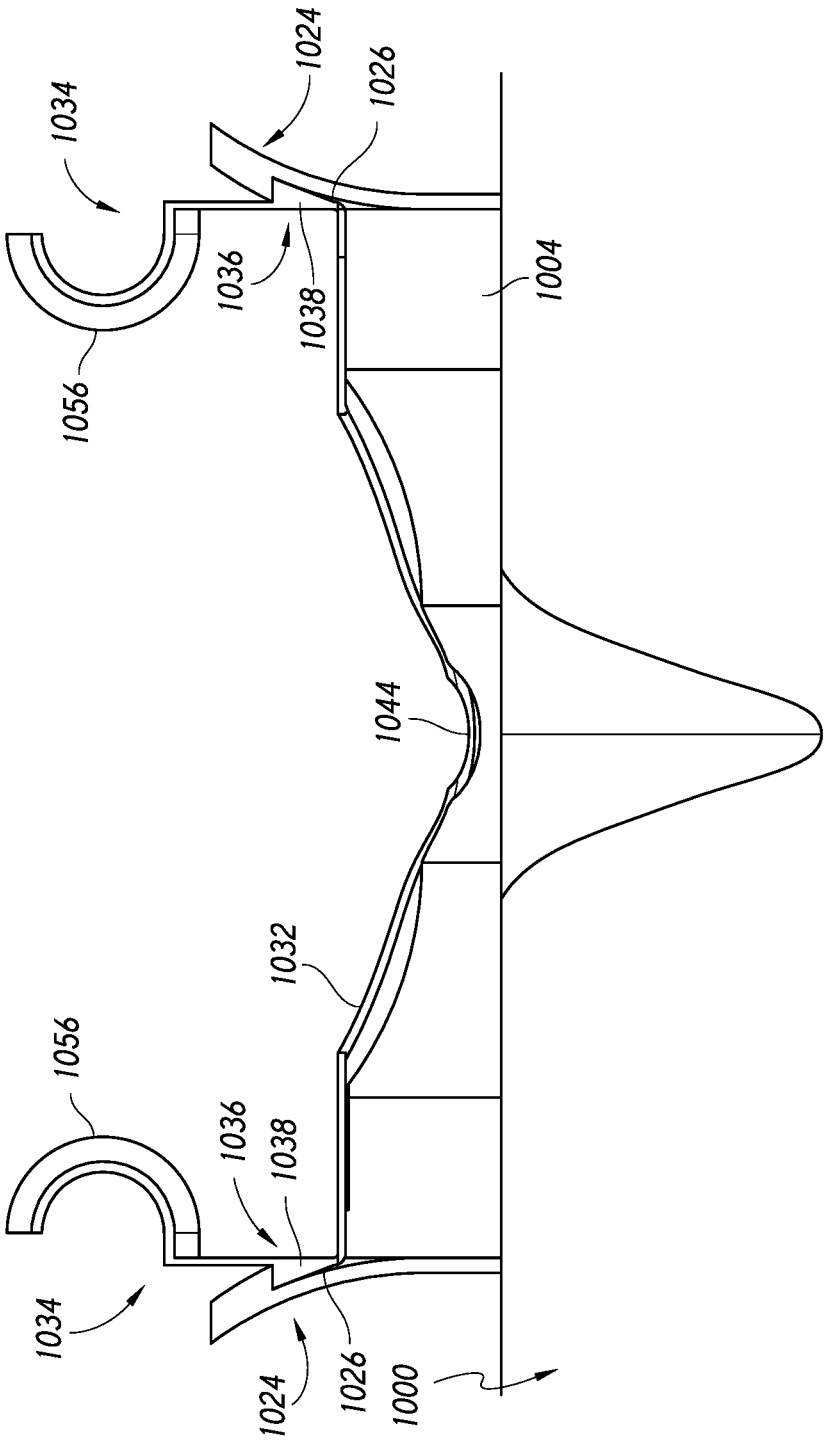

1024
1026
1034
1036
1038
1004
1056
1044
1032
1056
1036
1038
1034
1024
1026
1000

FIG. 33C

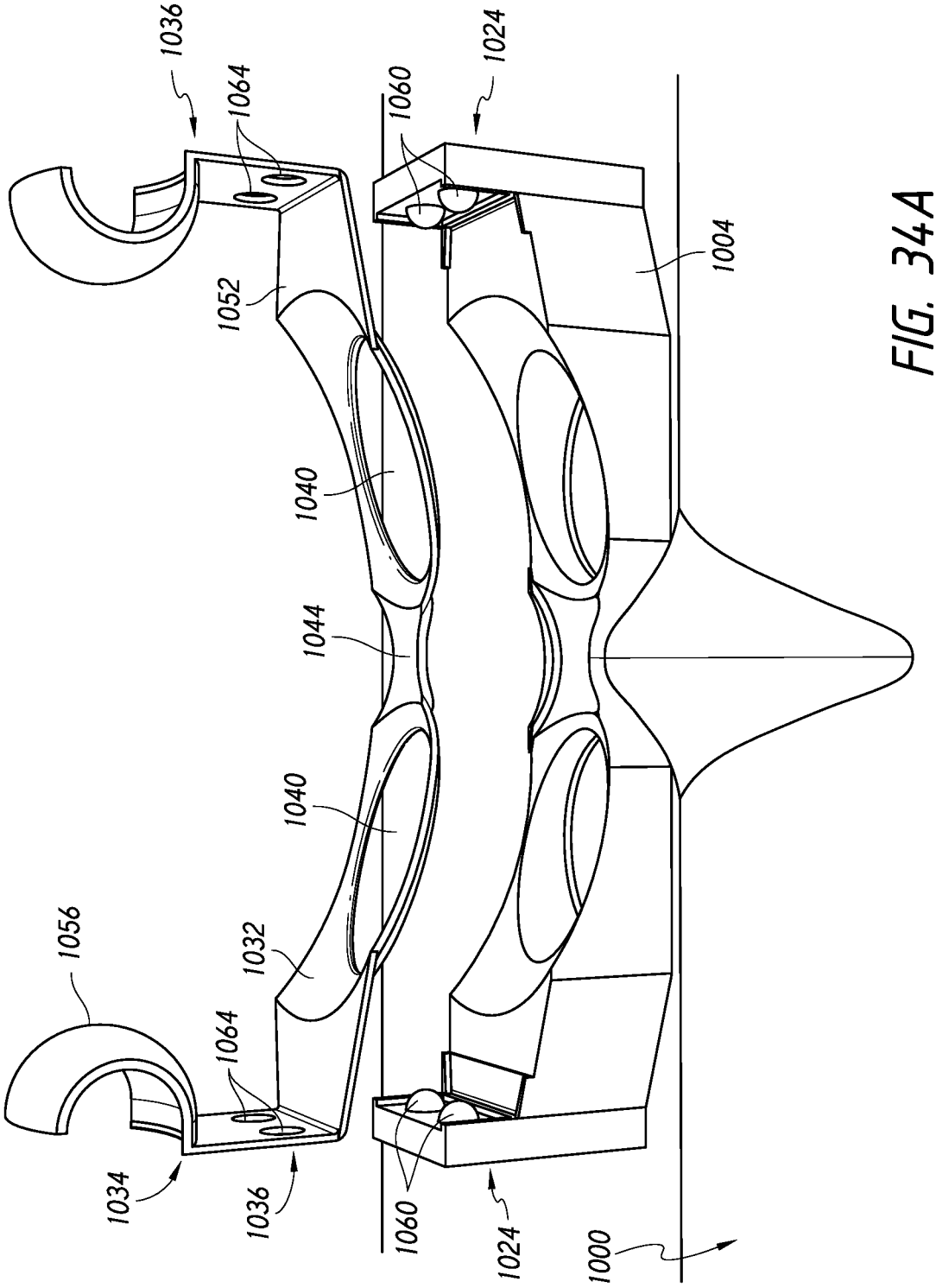

1036
1064
1060
1024
1052
1004
1040
1044
1040
1056
1032
1064
1034
1036
1060
1024
1000

FIG. 34A

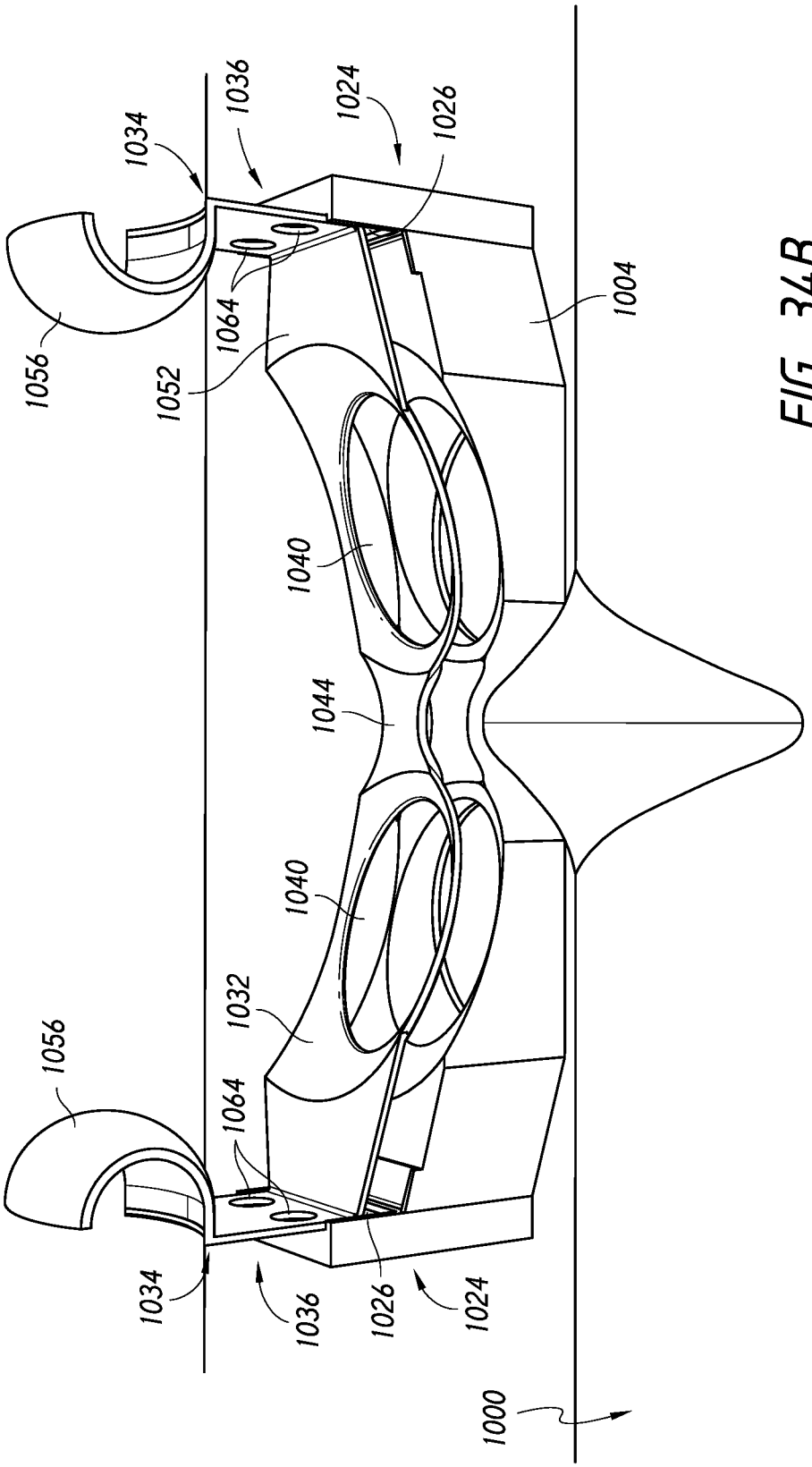

1034
1036
1024
1026
1004
1064
1056
1052
1040
1044
1040
1032
1056
1064
1034
1036
1026
1024
1000

FIG. 34B

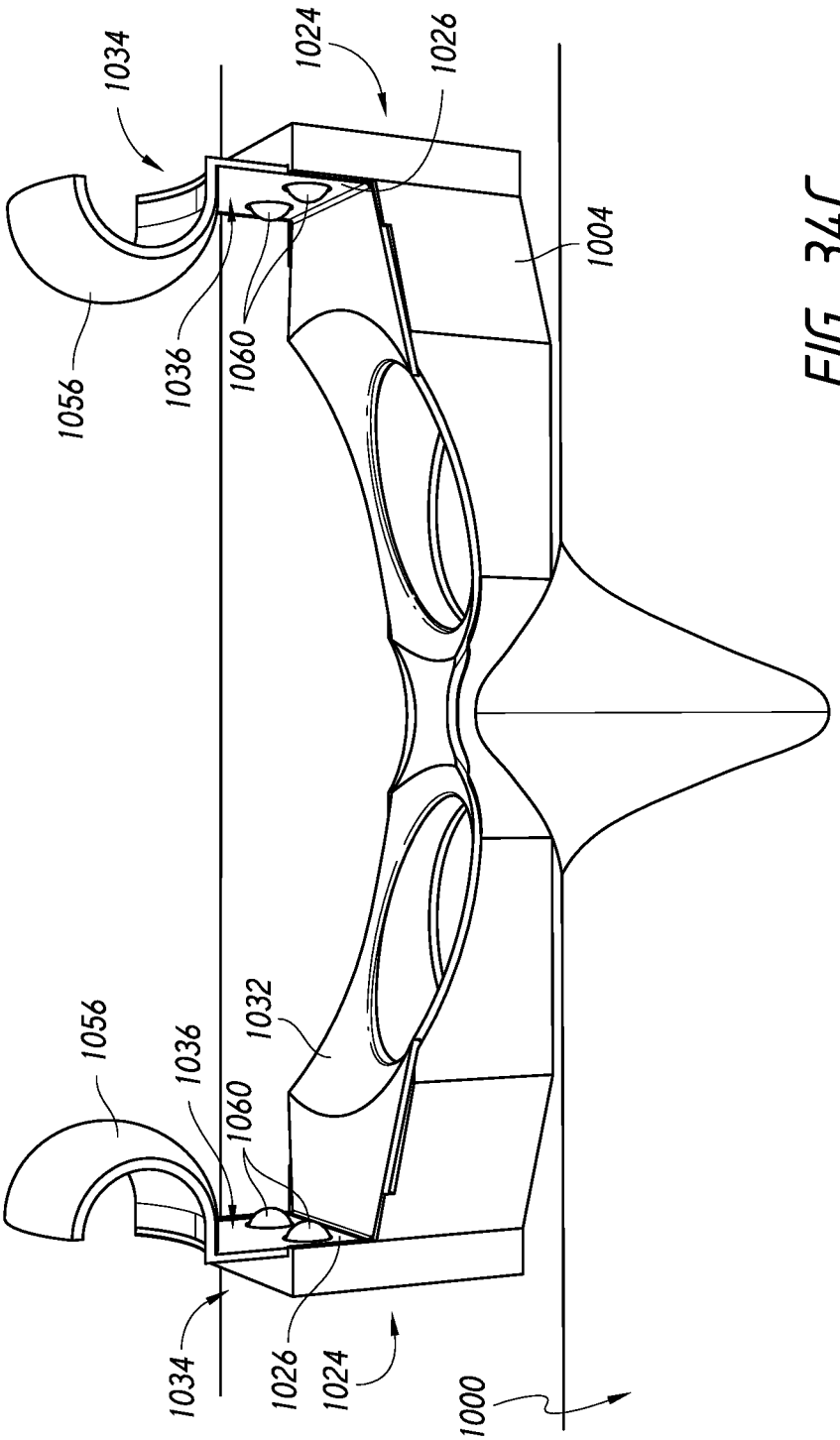


FIG. 34C

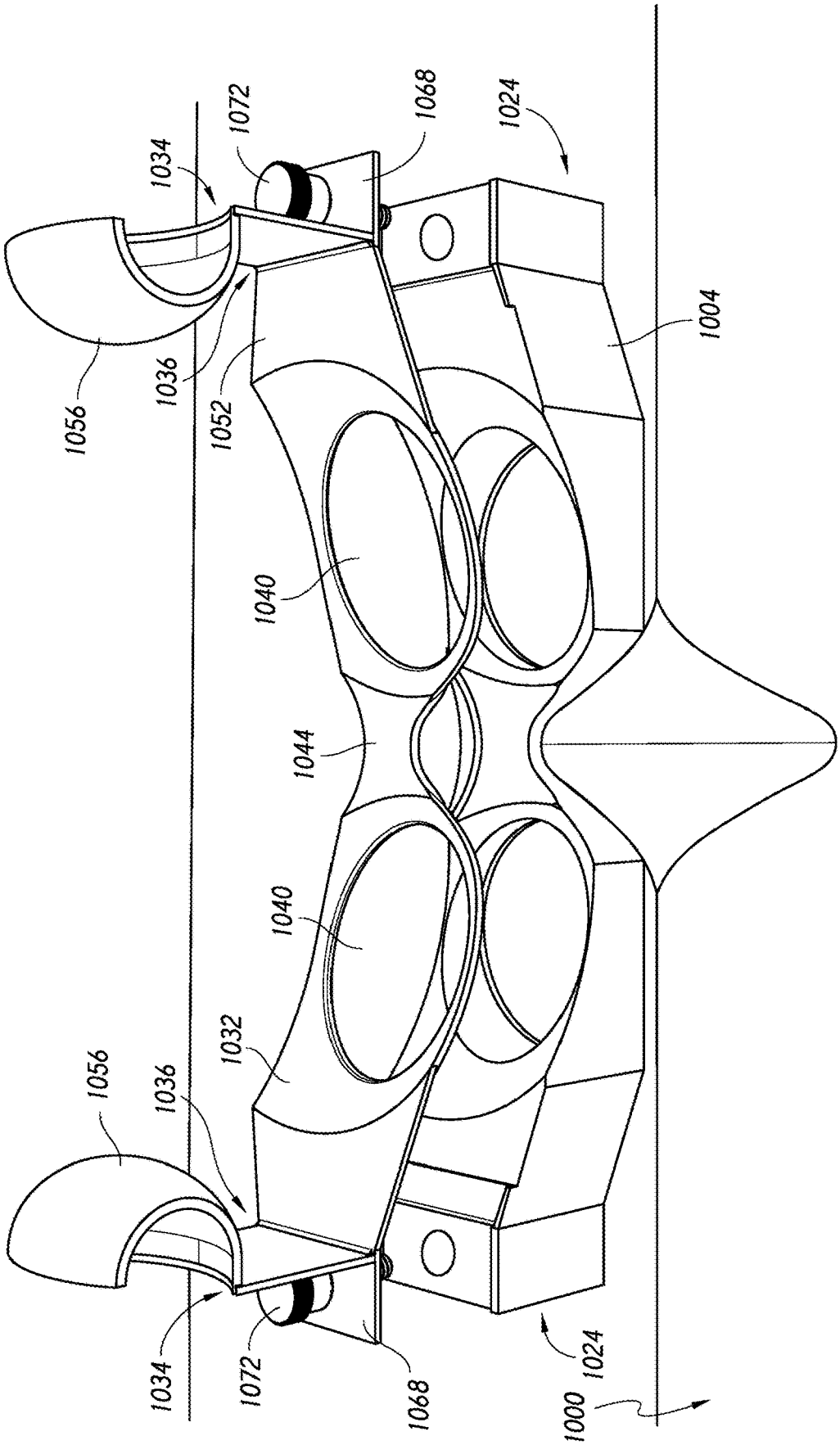

1072
1068
1024
1034
1004
1056
1036
1052
1040
1044
1040
1032
1056
1036
1034
1072
1068
1024
1000

FIG. 35A

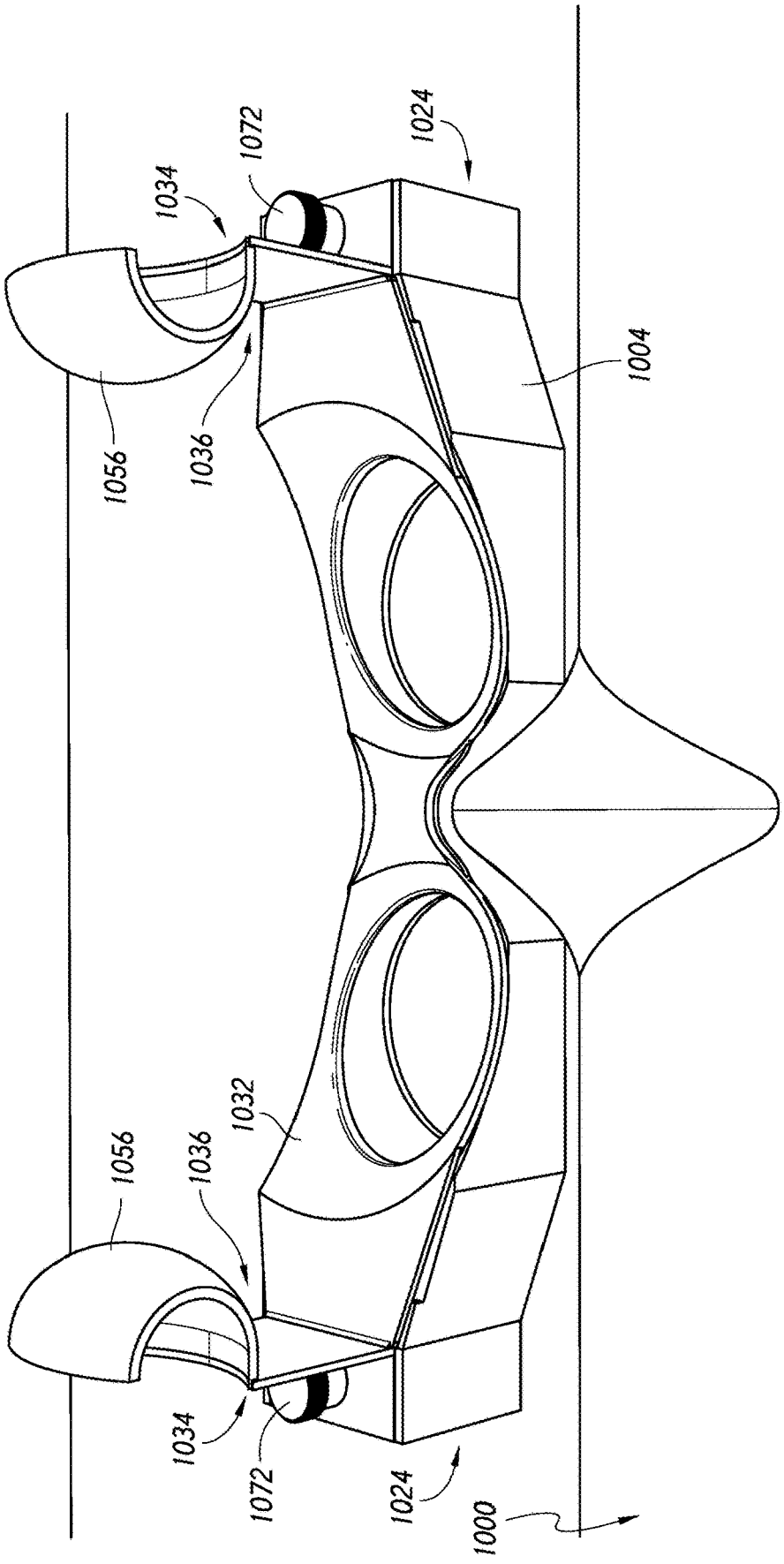

1072
1024
1034
1004
1056
1036
1032
1056
1036
1034
1072
1024
1000

FIG. 35B

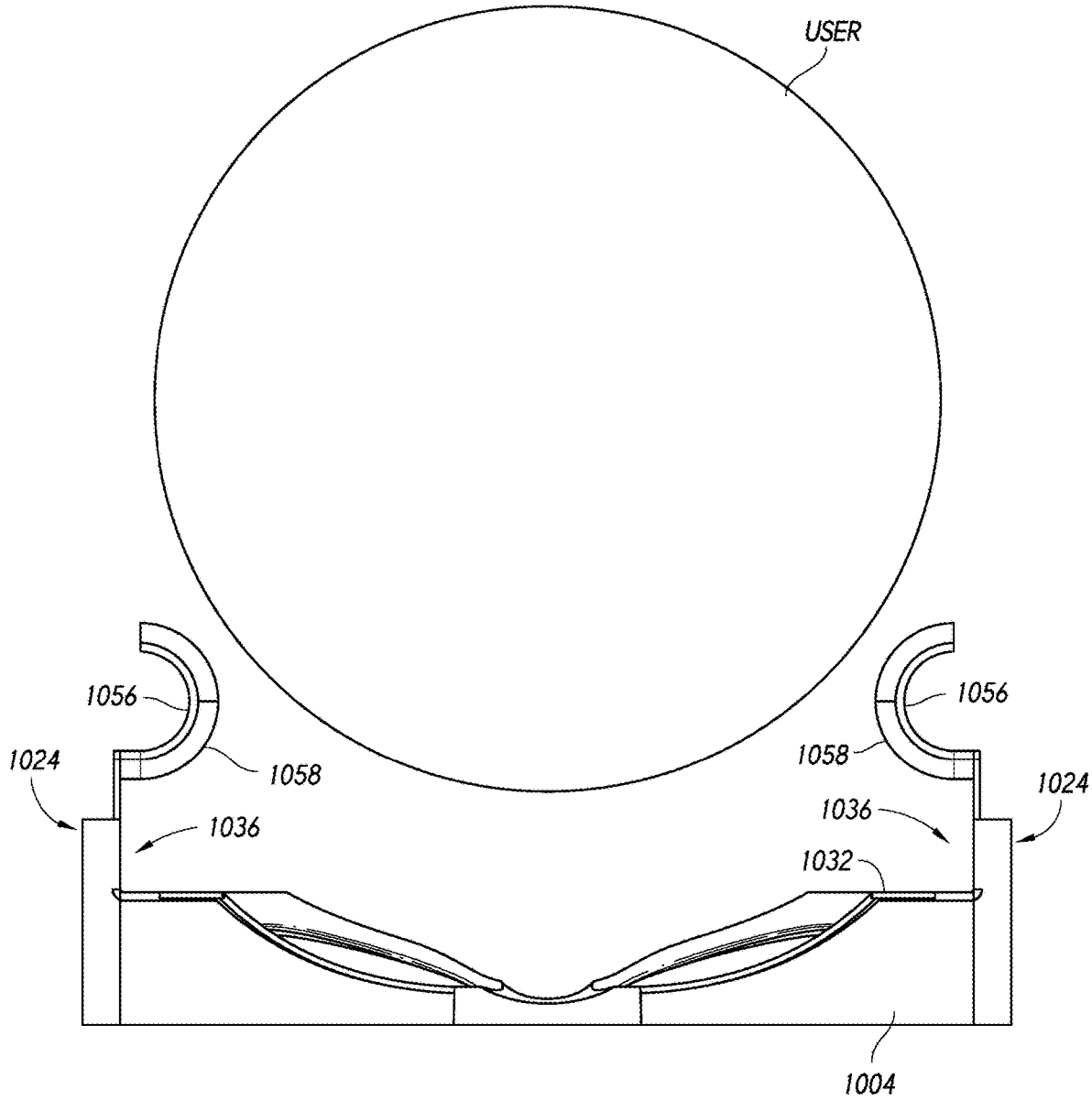


FIG. 36A

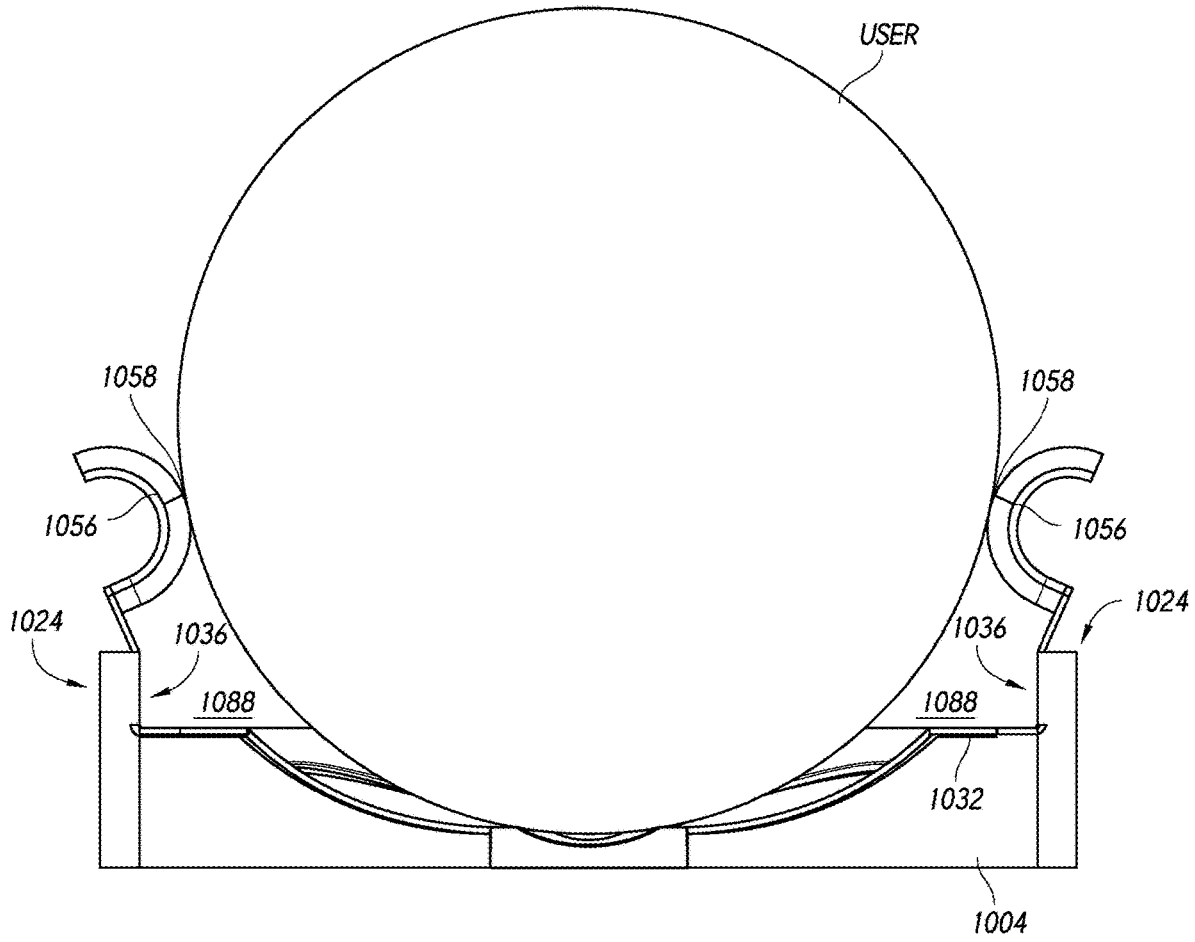

USER
1058
1058
1056
1056
1024
1024
1036
1036
1088
1088
1032
1004

FIG. 36B

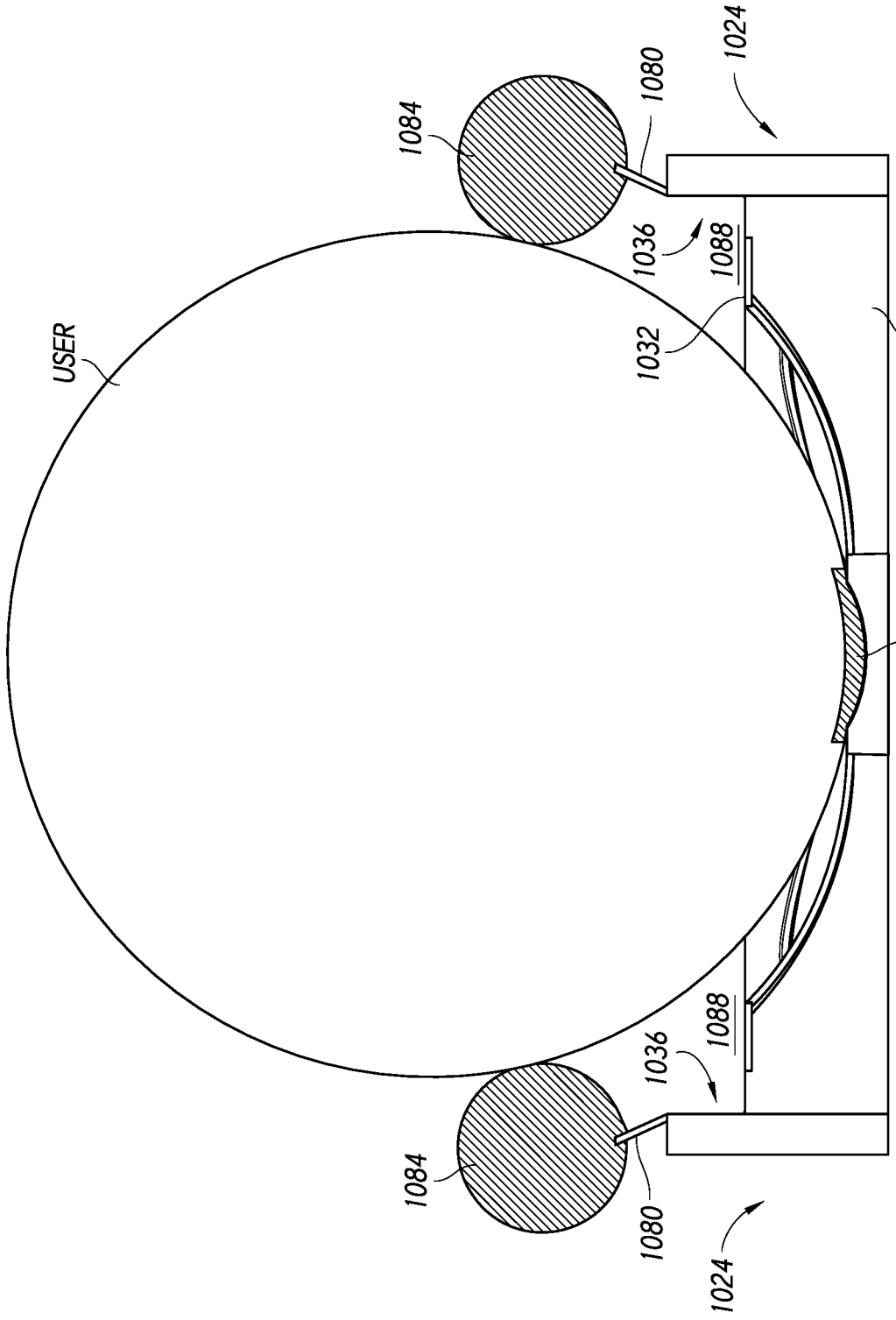


FIG. 37

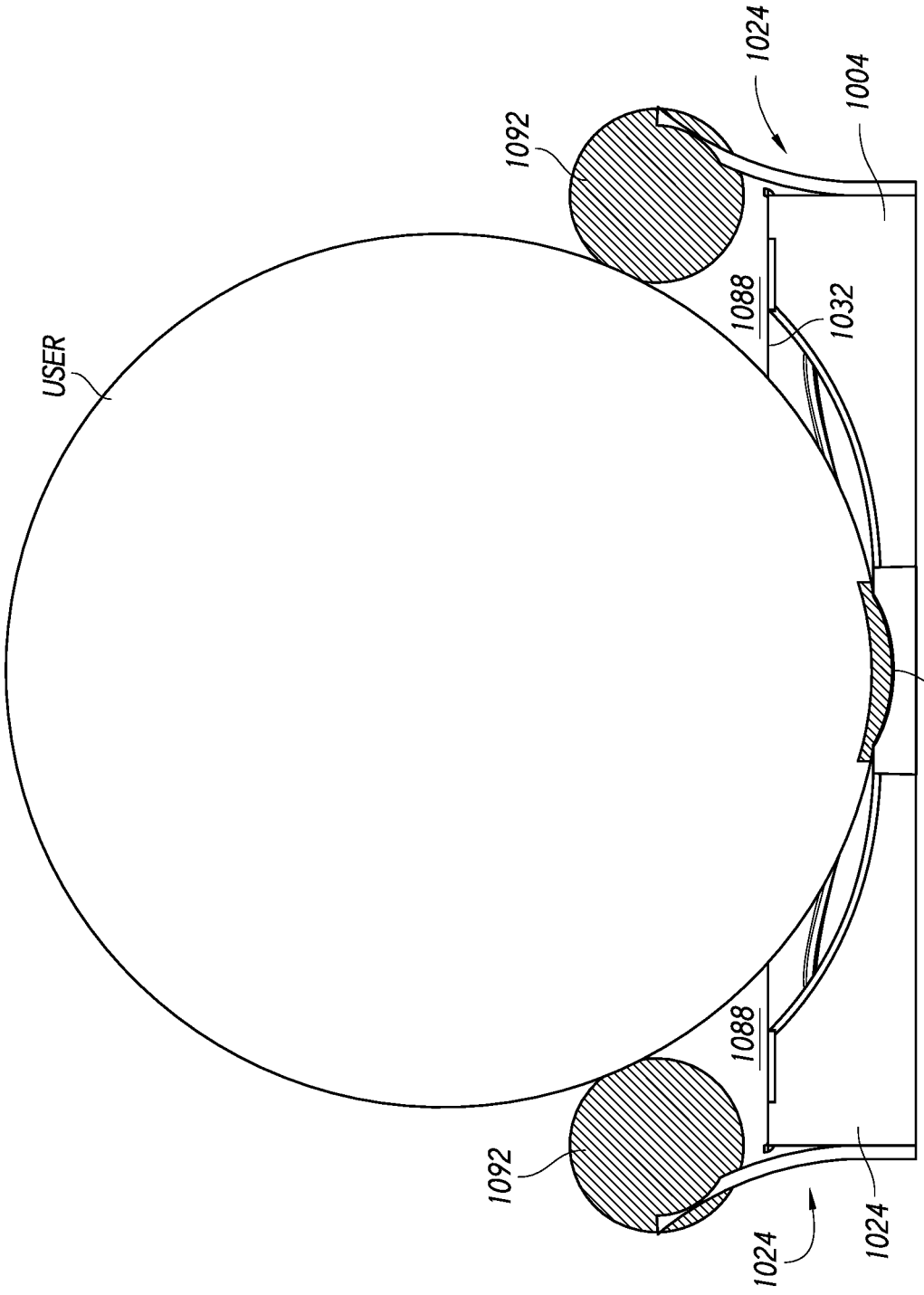


FIG. 38

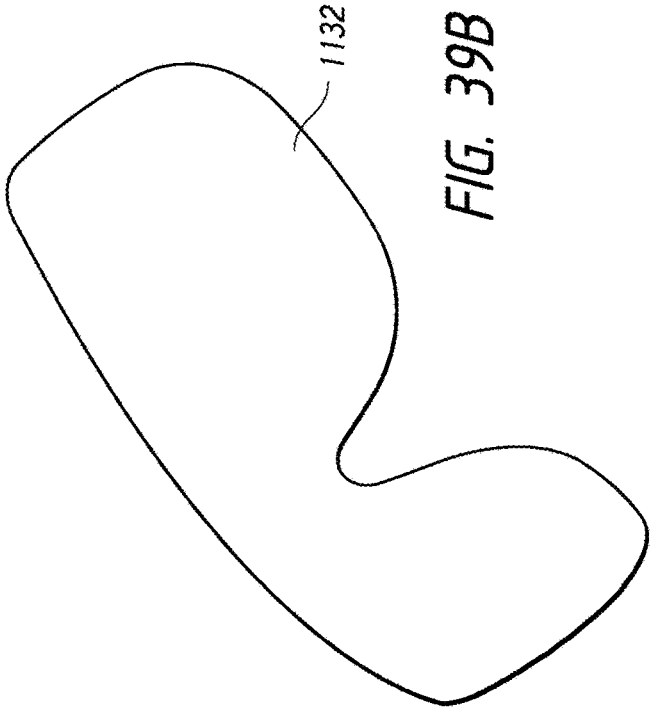


FIG. 39B

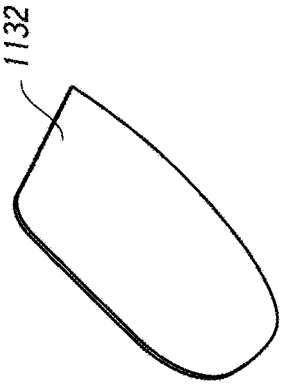


FIG. 39D

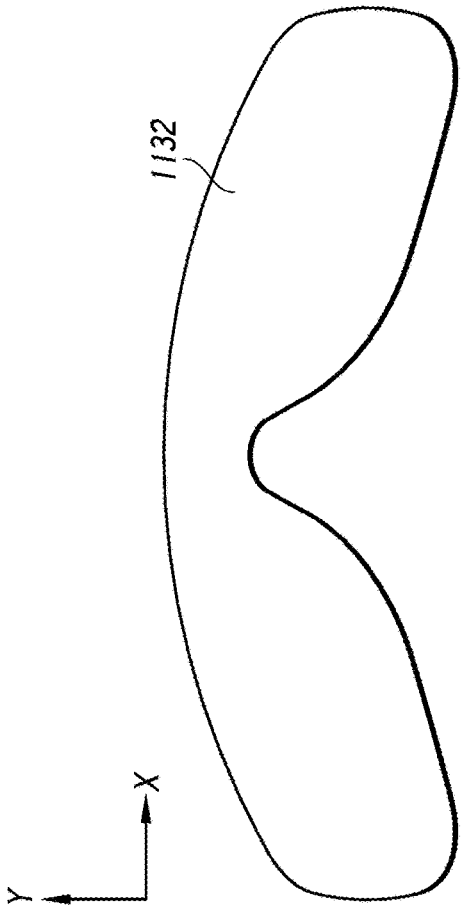


FIG. 39A

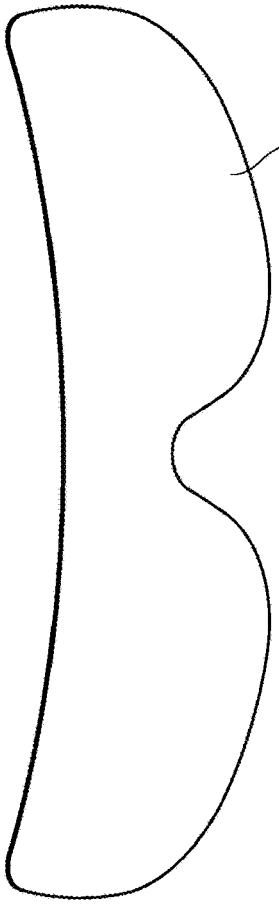


FIG. 39C

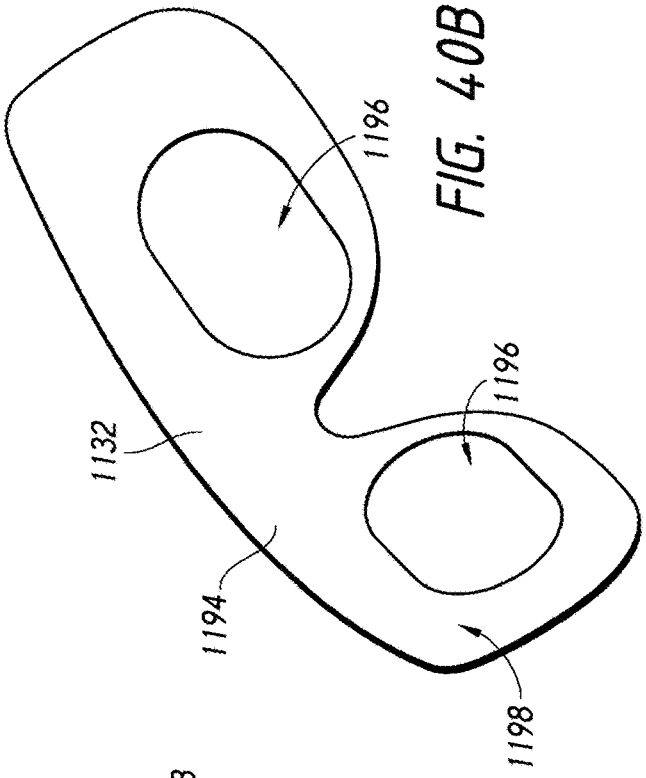


FIG. 40B

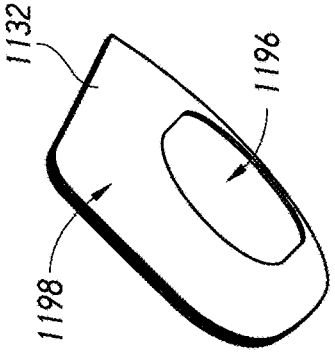


FIG. 40D

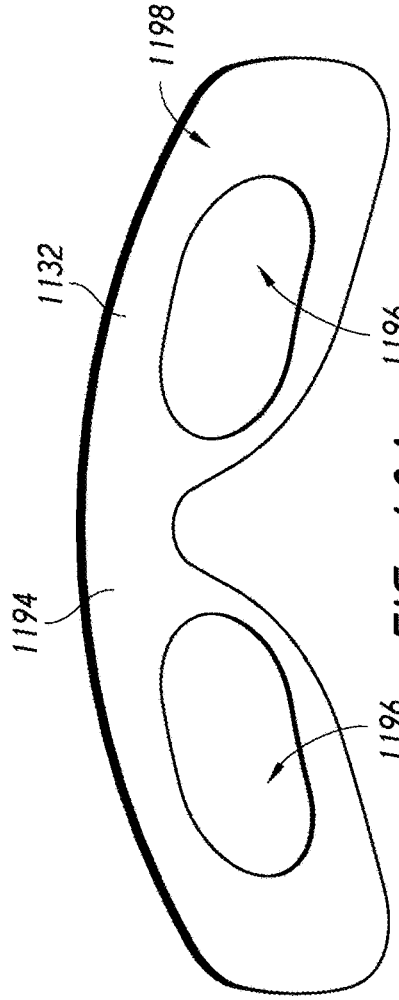


FIG. 40A

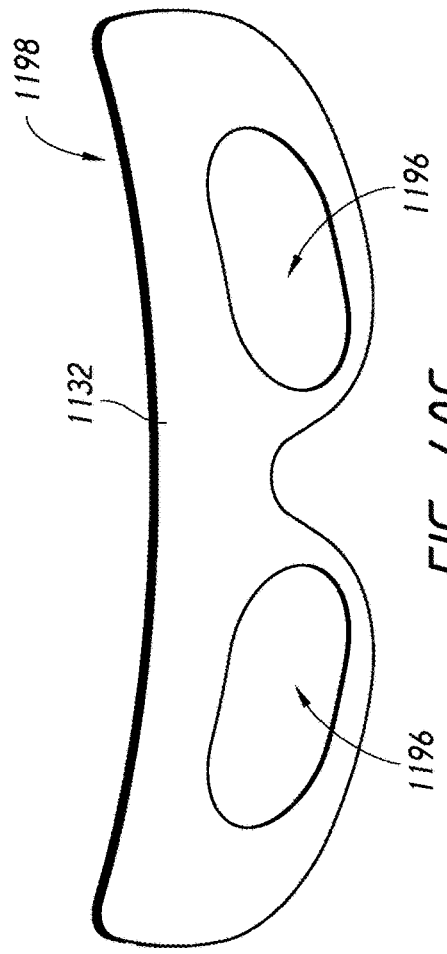


FIG. 40C

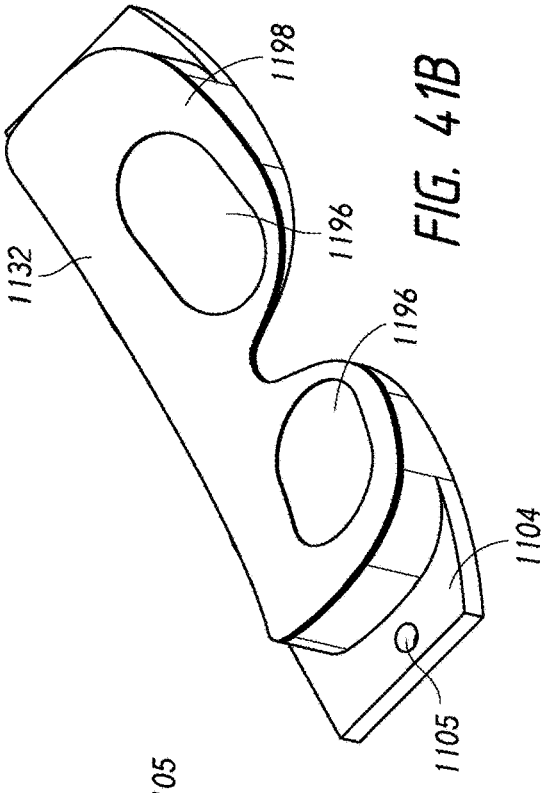


FIG. 41B

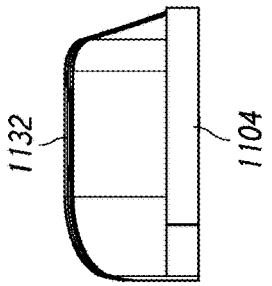


FIG. 41D

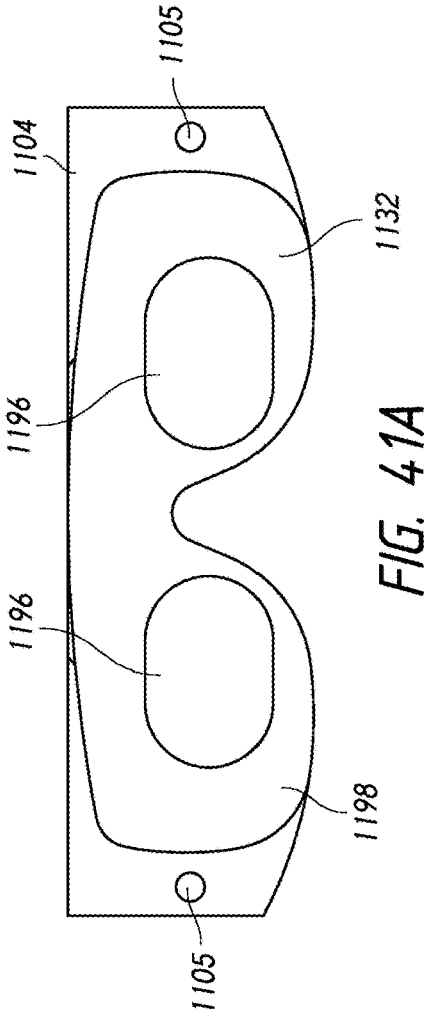


FIG. 41A

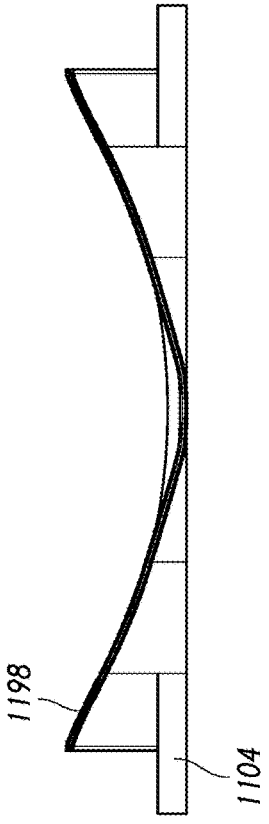


FIG. 41C

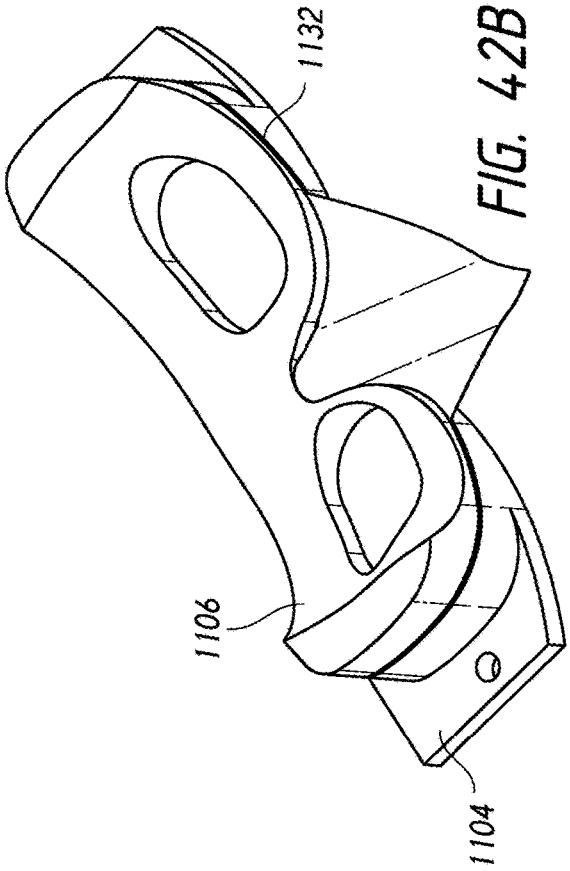


FIG. 42B

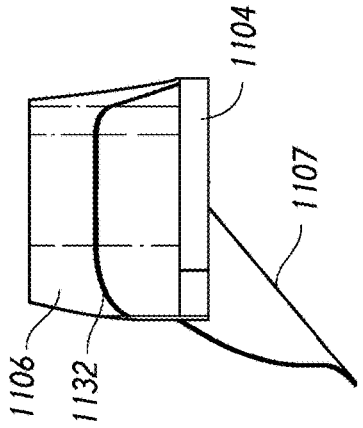


FIG. 42D

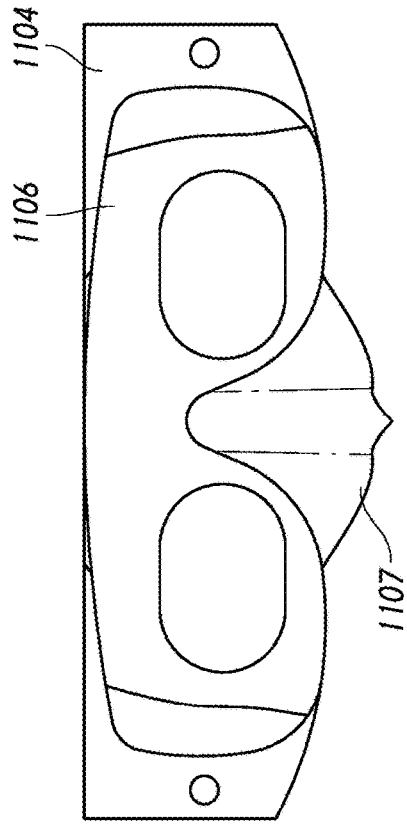


FIG. 42A

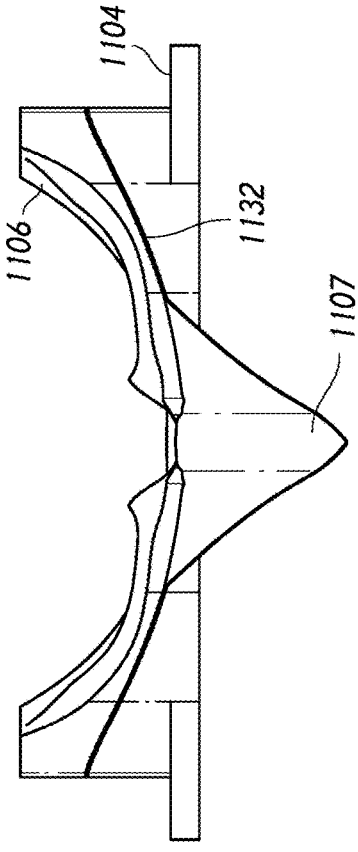


FIG. 42C

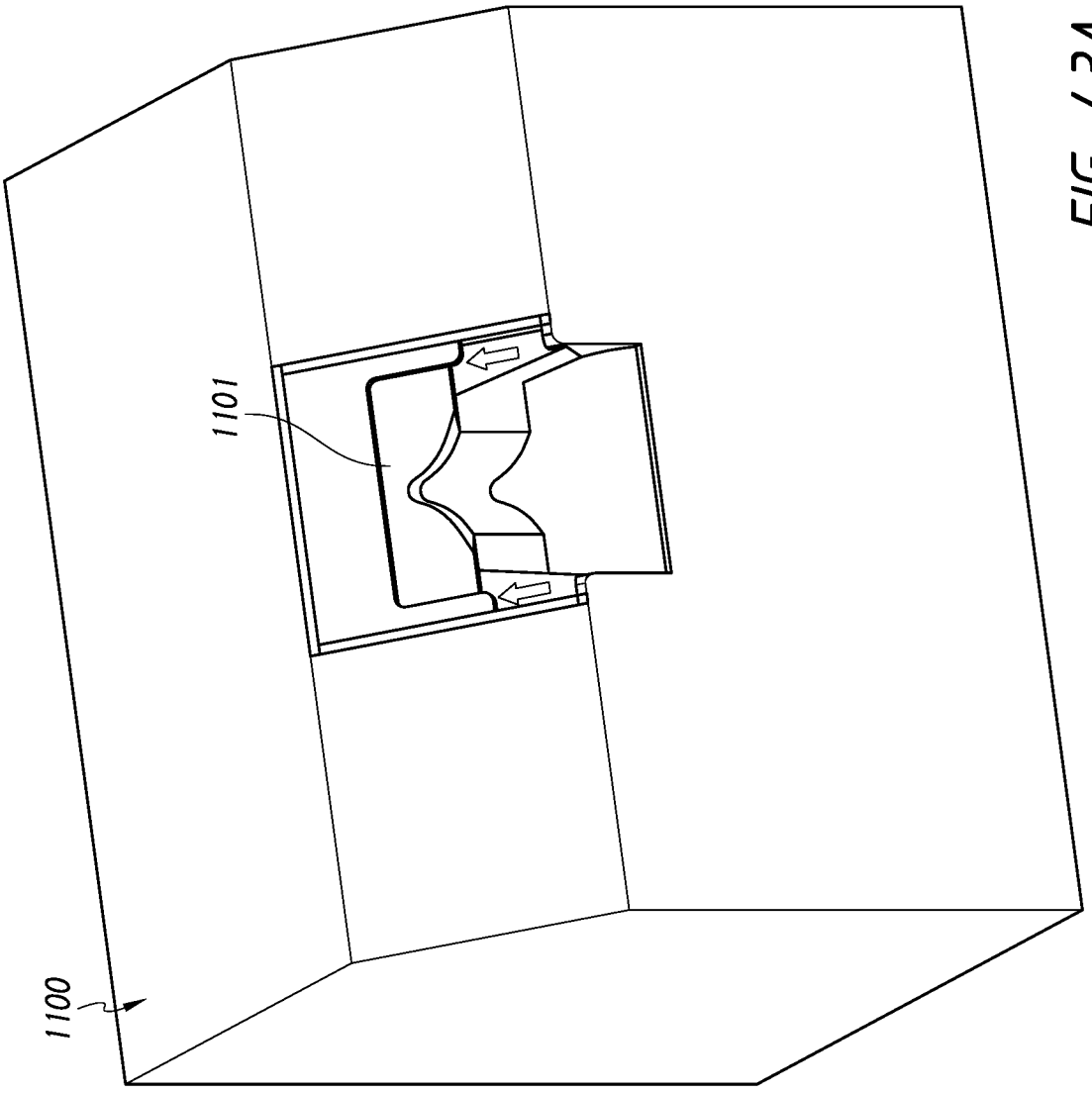


FIG. 43A

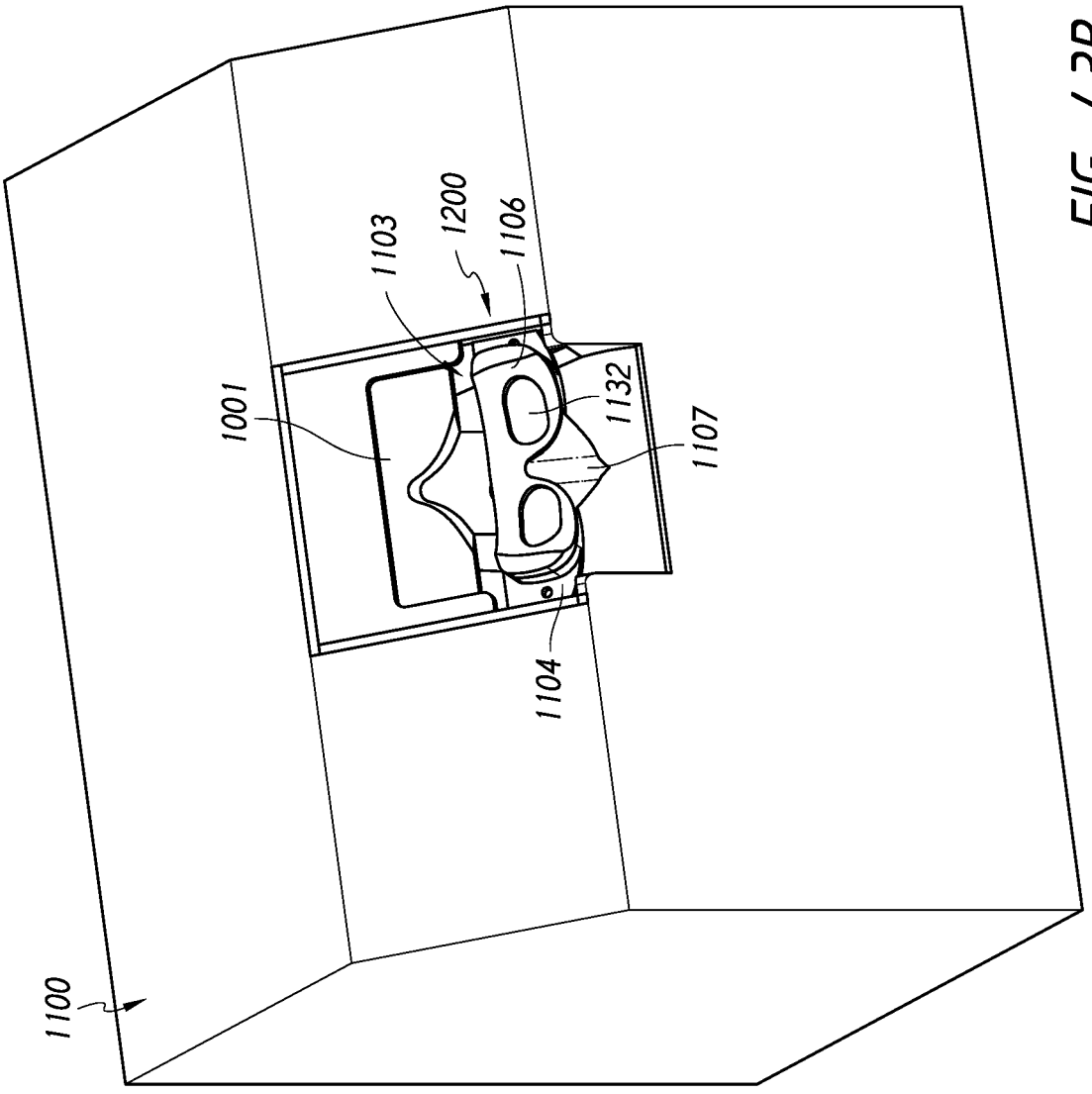


FIG. 43B

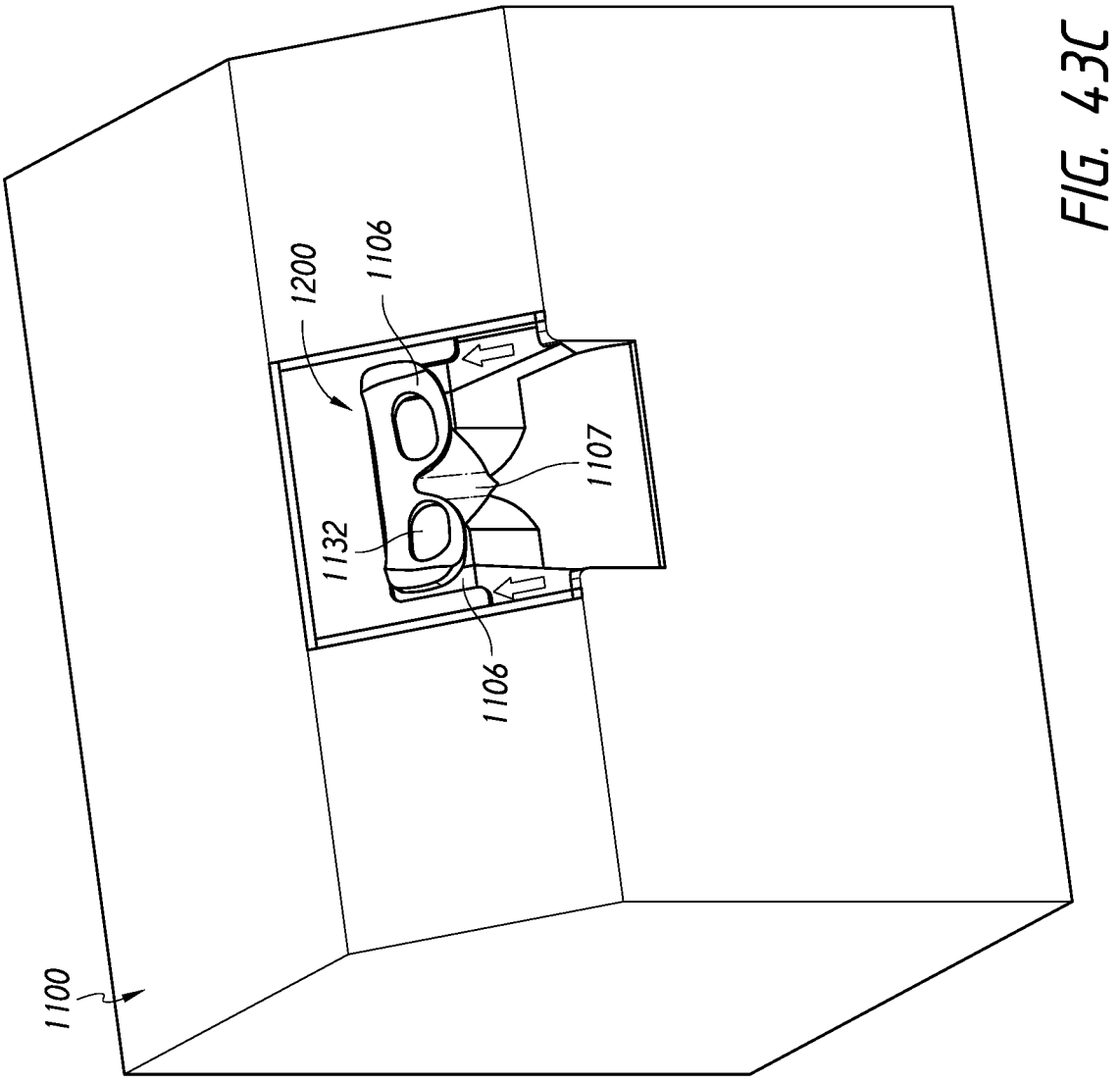


FIG. 43C

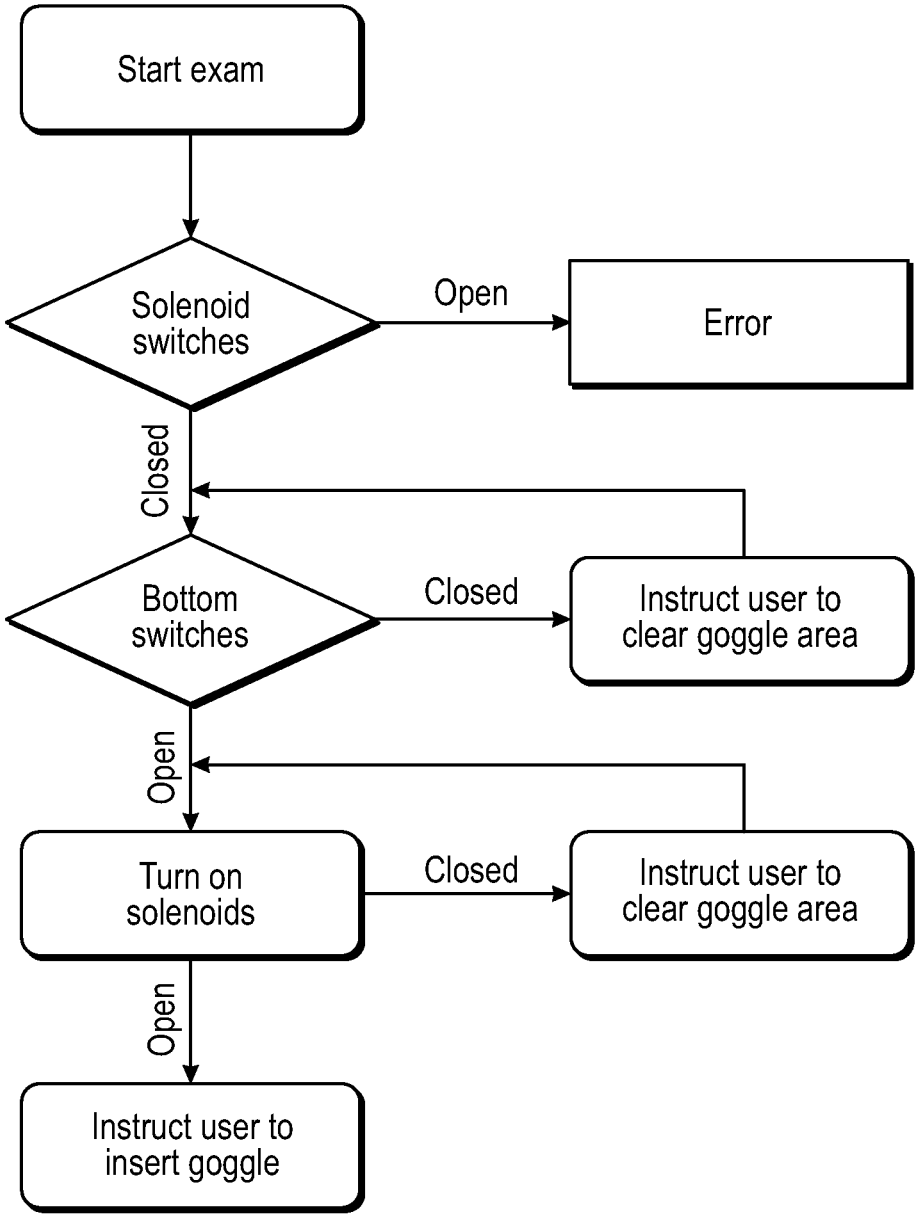

Start exam
Solenoid switches
Open
Error
Closed
Bottom switches
Closed
Instruct user to clear goggle area
Open
Turn on solenoids
Closed
Instruct user to clear goggle area
Open
Instruct user to insert goggle

FIG. 44

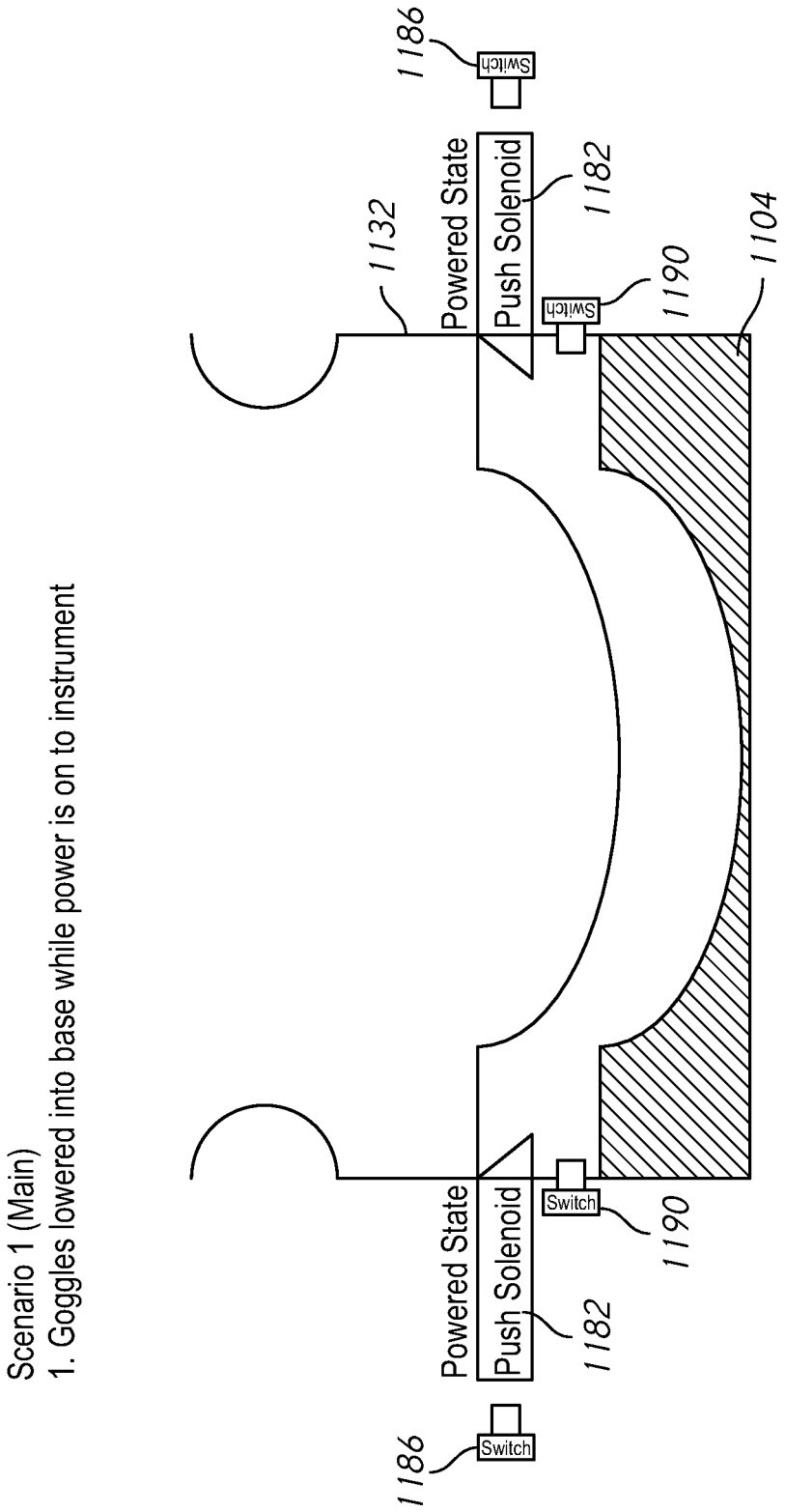

Scenario 1 (Main)
1. Goggles lowered into base while power is on to instrument
1186
Switch
Powered State
Push Solenoid
1182
1132
1190
Switch
1104
Switch
1190
Powered State
Push Solenoid
1182
1186
Switch

FIG. 44A

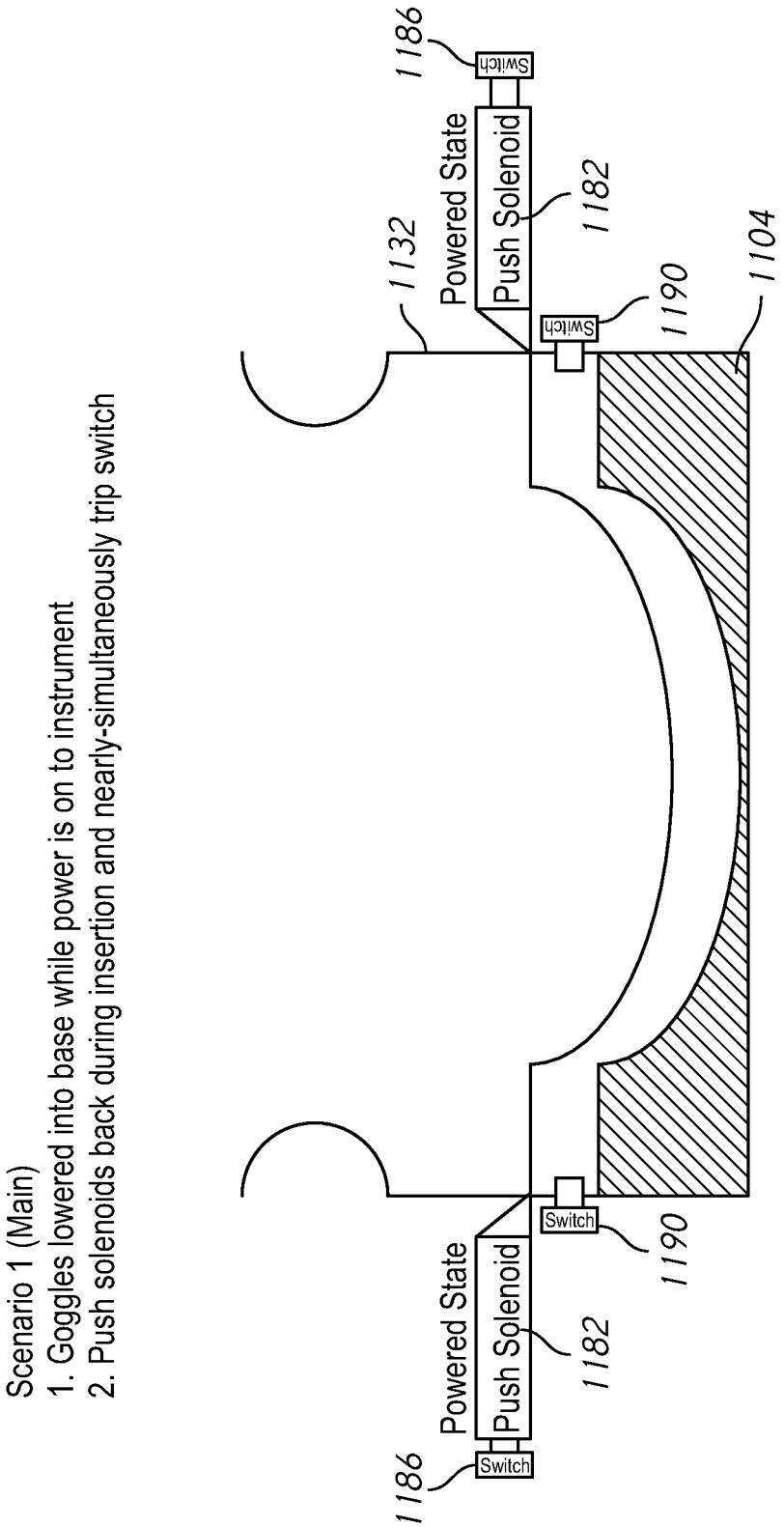

Scenario 1 (Main)
1. Goggles lowered into base while power is on to instrument
2. Push solenoids back during insertion and nearly-simultaneously trip switch
1186
Switch
Powered State
Push Solenoid
1182
1132
1190
Switch
1104
Switch
1190
Powered State
Push Solenoid
1182
1186
Switch

FIG. 44B

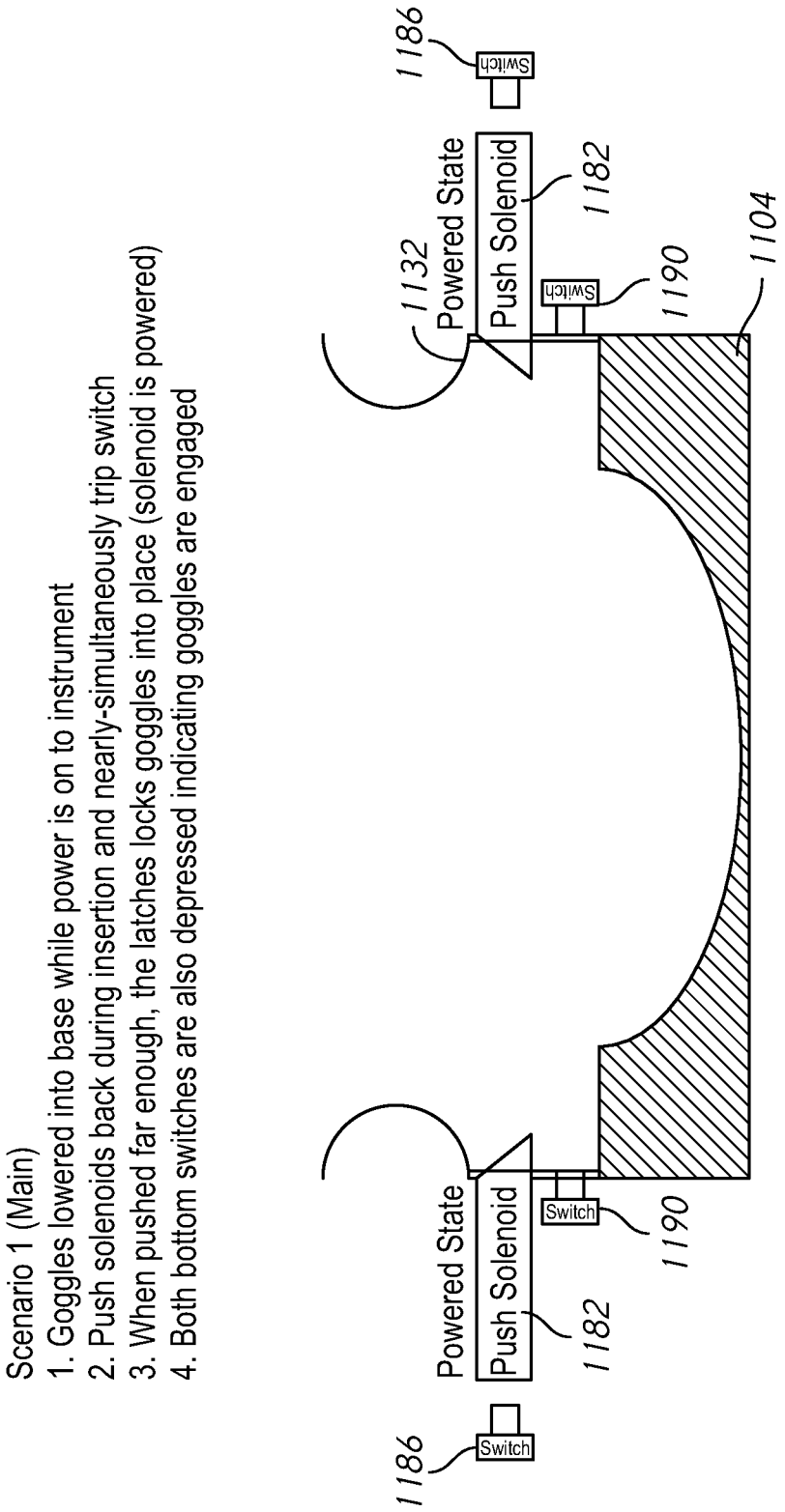

Scenario 1 (Main)
1. Goggles lowered into base while power is on to instrument
2. Push solenoids back during insertion and nearly-simultaneously trip switch
3. When pushed far enough, the latches locks goggles into place (solenoid is powered)
4. Both bottom switches are also depressed indicating goggles are engaged
1186
Switch
Powered State
Push Solenoid
1182
1190
Switch
1132
Powered State
Push Solenoid
1182
1190
Switch
1186
Switch
1104

FIG. 44C

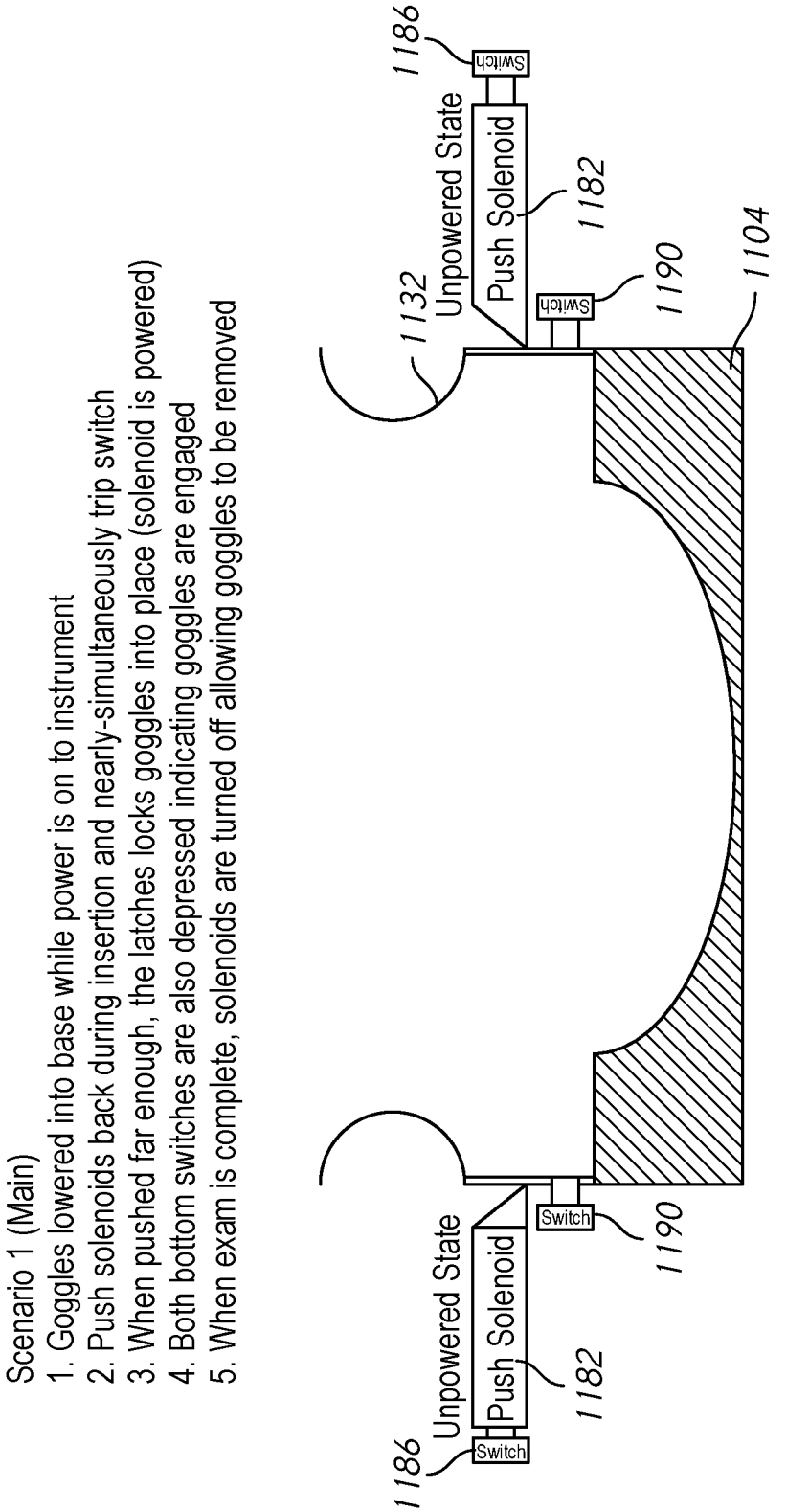

Scenario 1 (Main)
1. Goggles lowered into base while power is on to instrument
2. Push solenoids back during insertion and nearly-simultaneously trip switch
3. When pushed far enough, the latches locks goggles into place (solenoid is powered)
4. Both bottom switches are also depressed indicating goggles are engaged
5. When exam is complete, solenoids are turned off allowing goggles to be removed
1186
Switch
Unpowered State
Push Solenoid
1182
1132
Switch
1190
1104
Switch
1190
Unpowered State
Push Solenoid
1182
1186
Switch

FIG. 44D

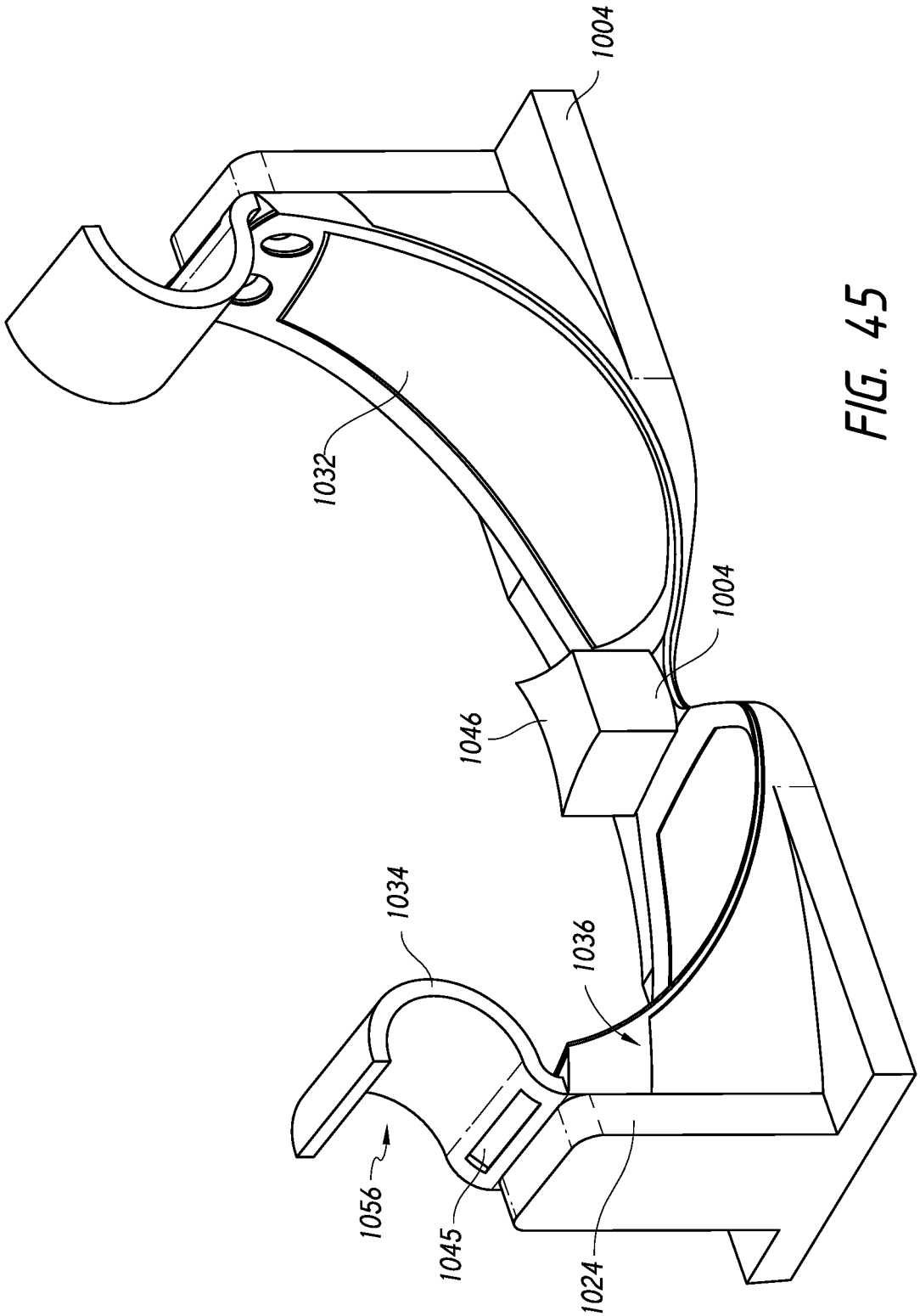


FIG. 45

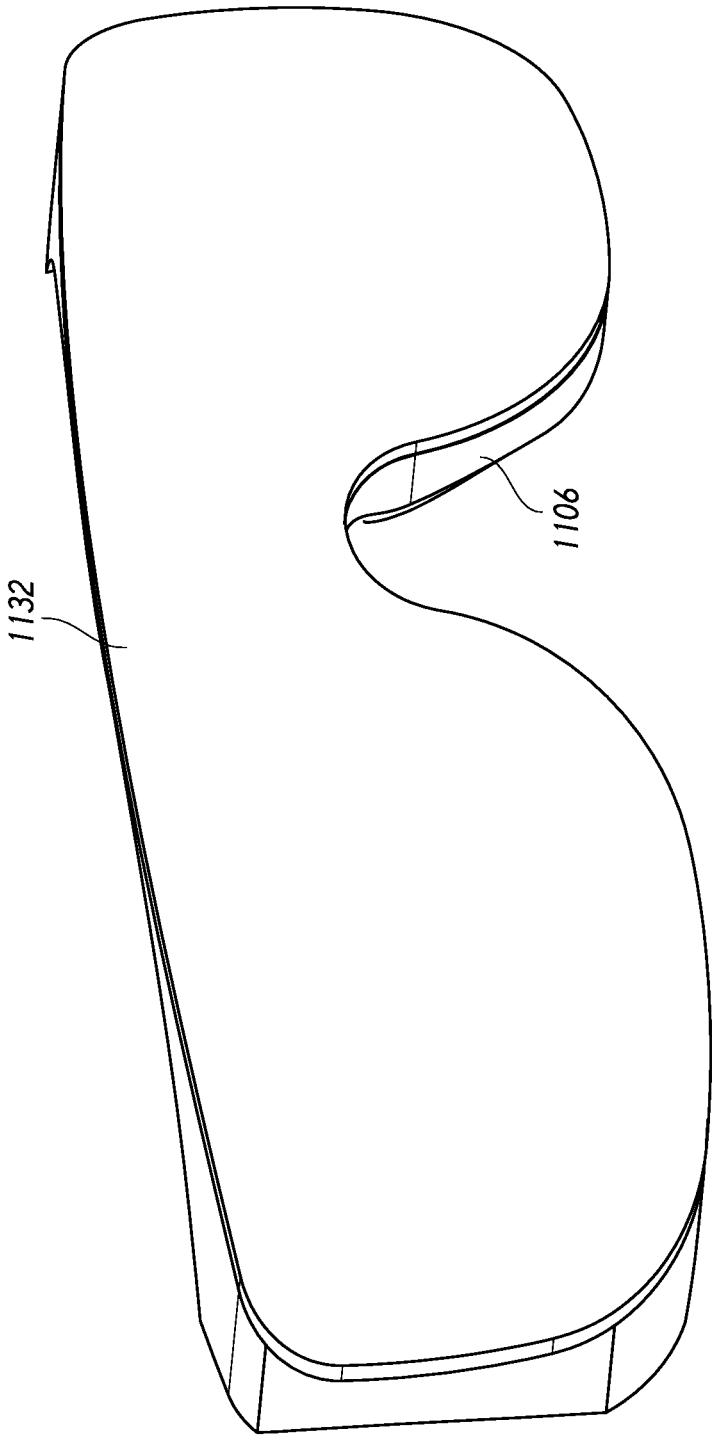


FIG. 46A

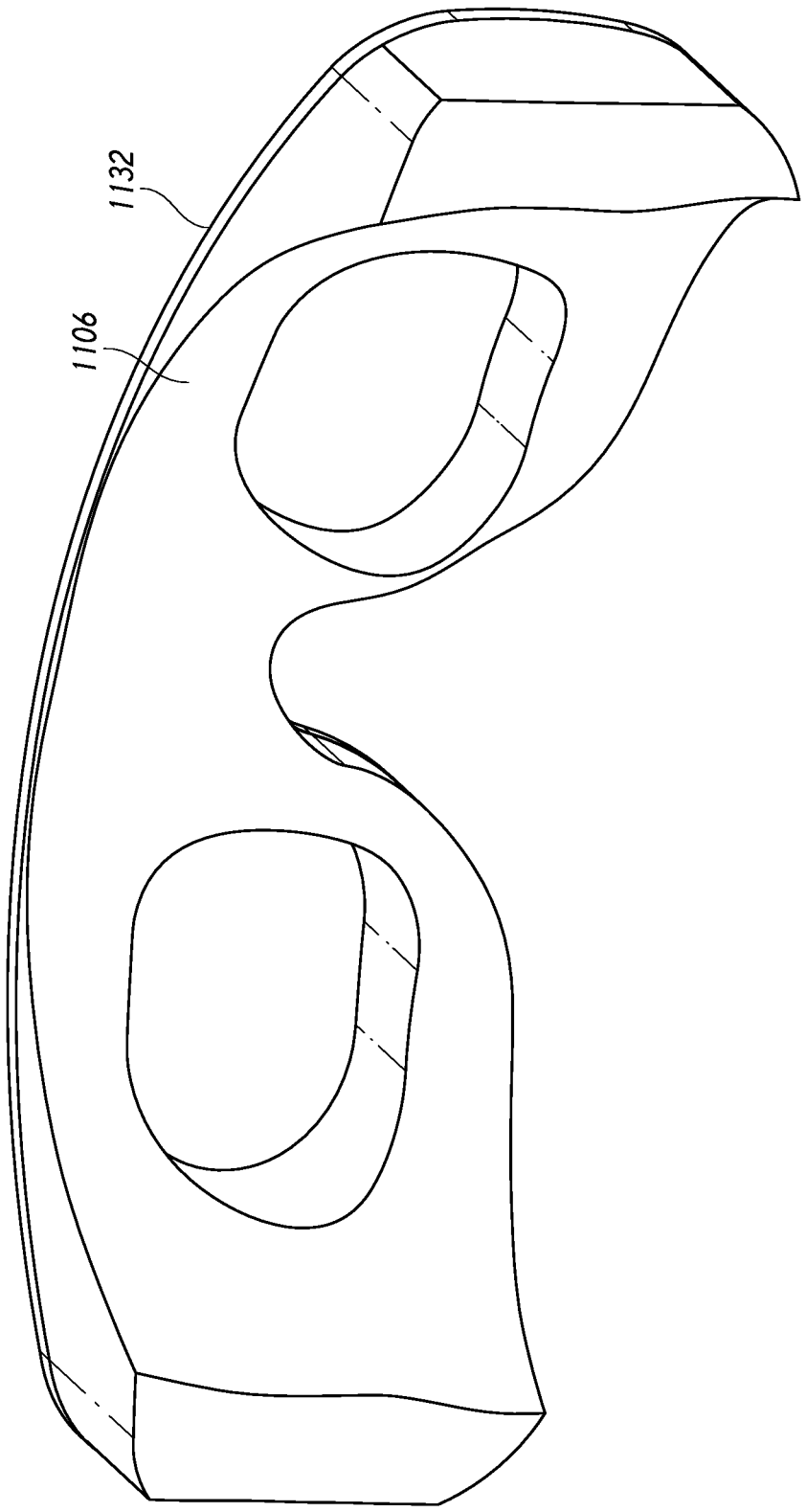


FIG. 46B

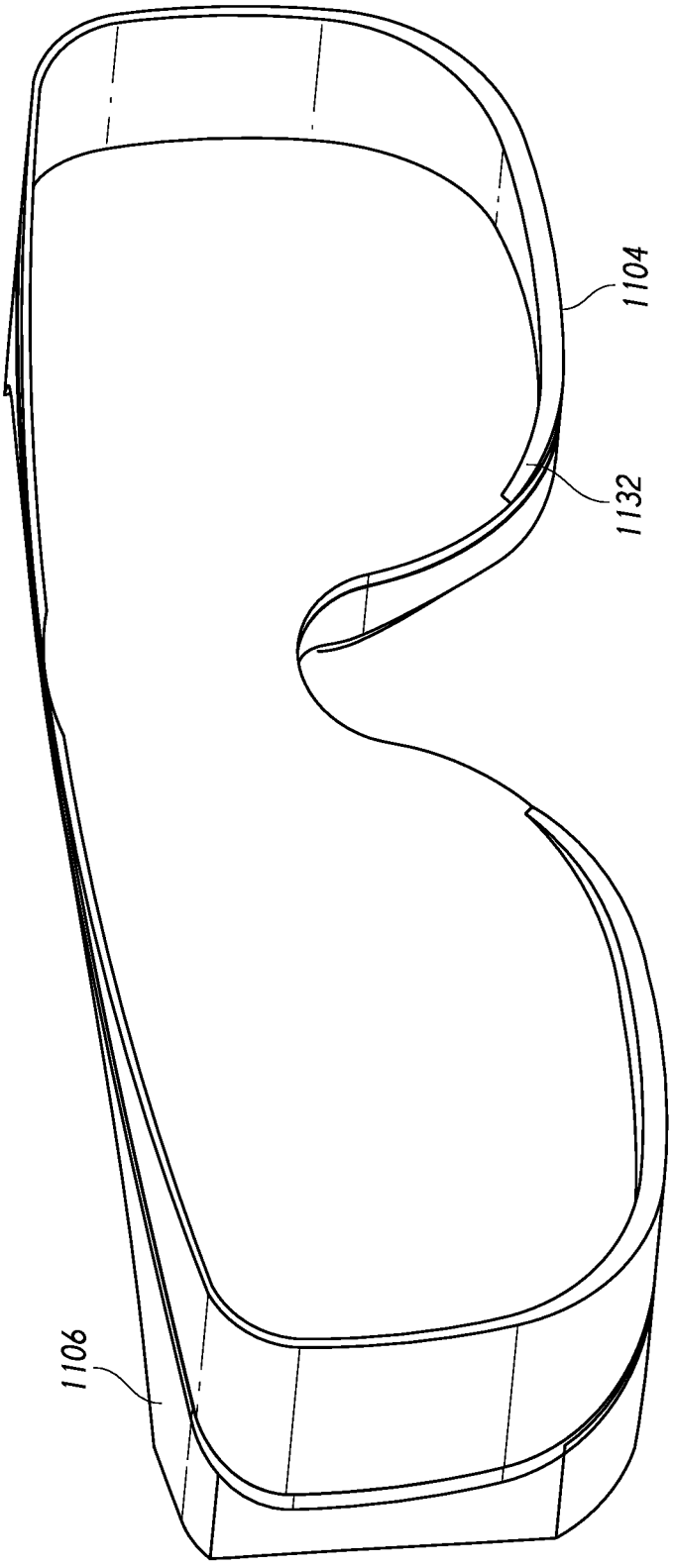


FIG. 47A

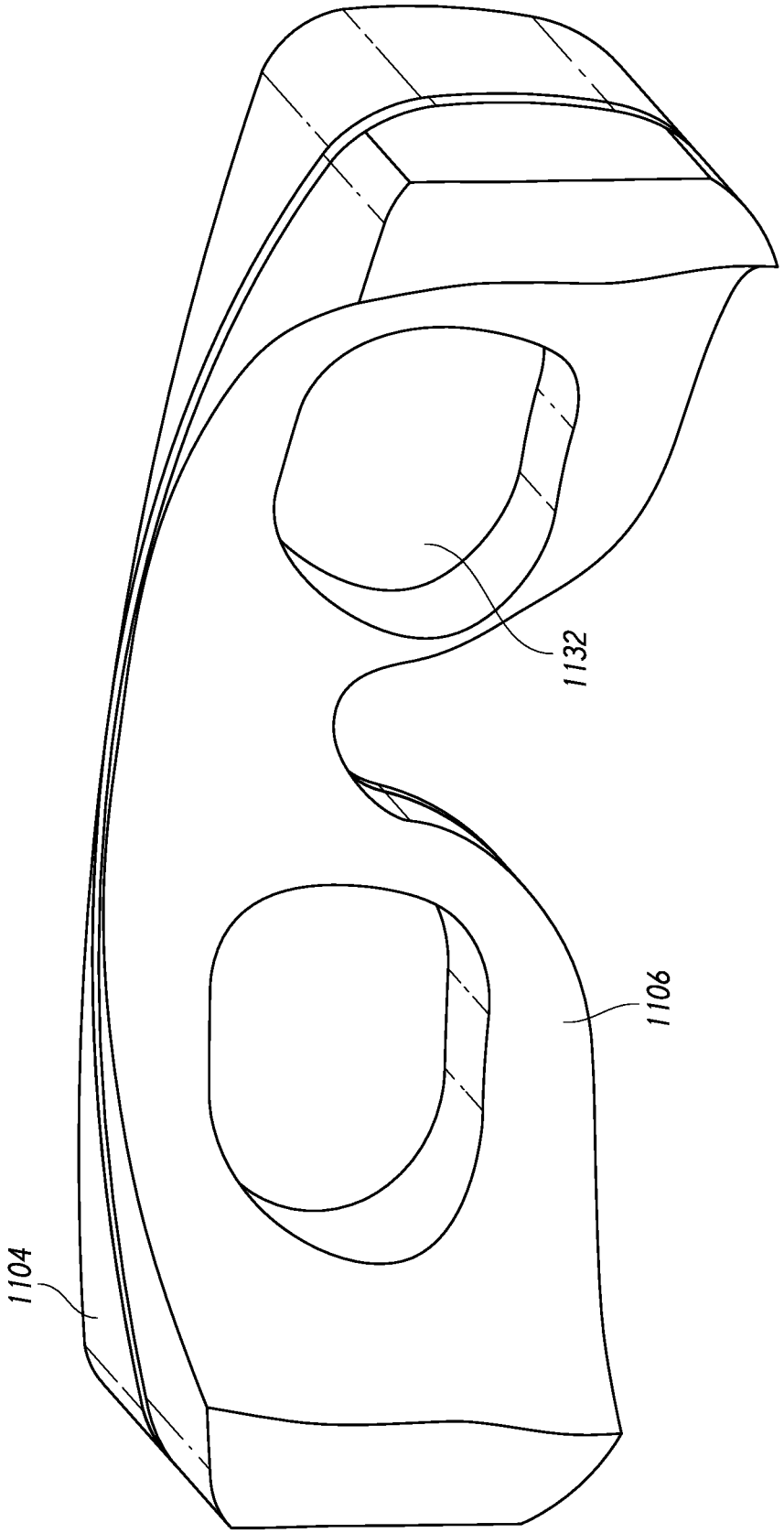


FIG. 47B

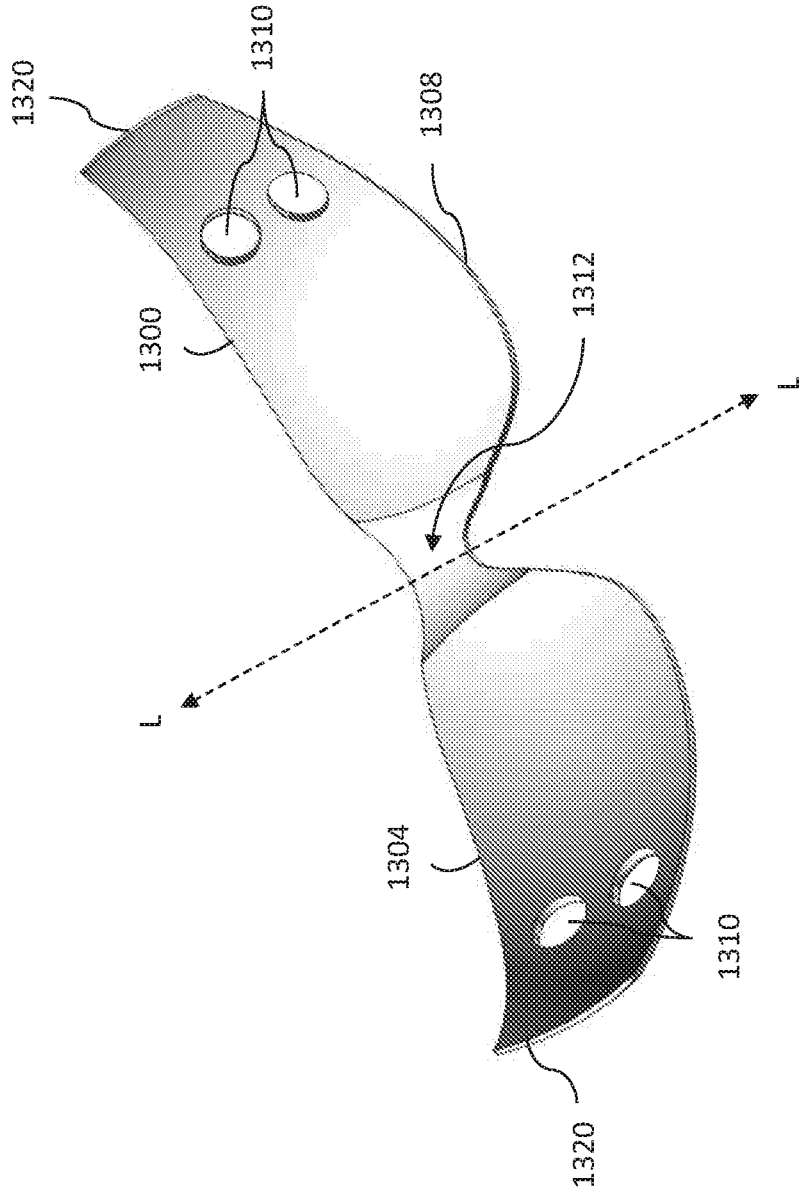


FIG. 48A

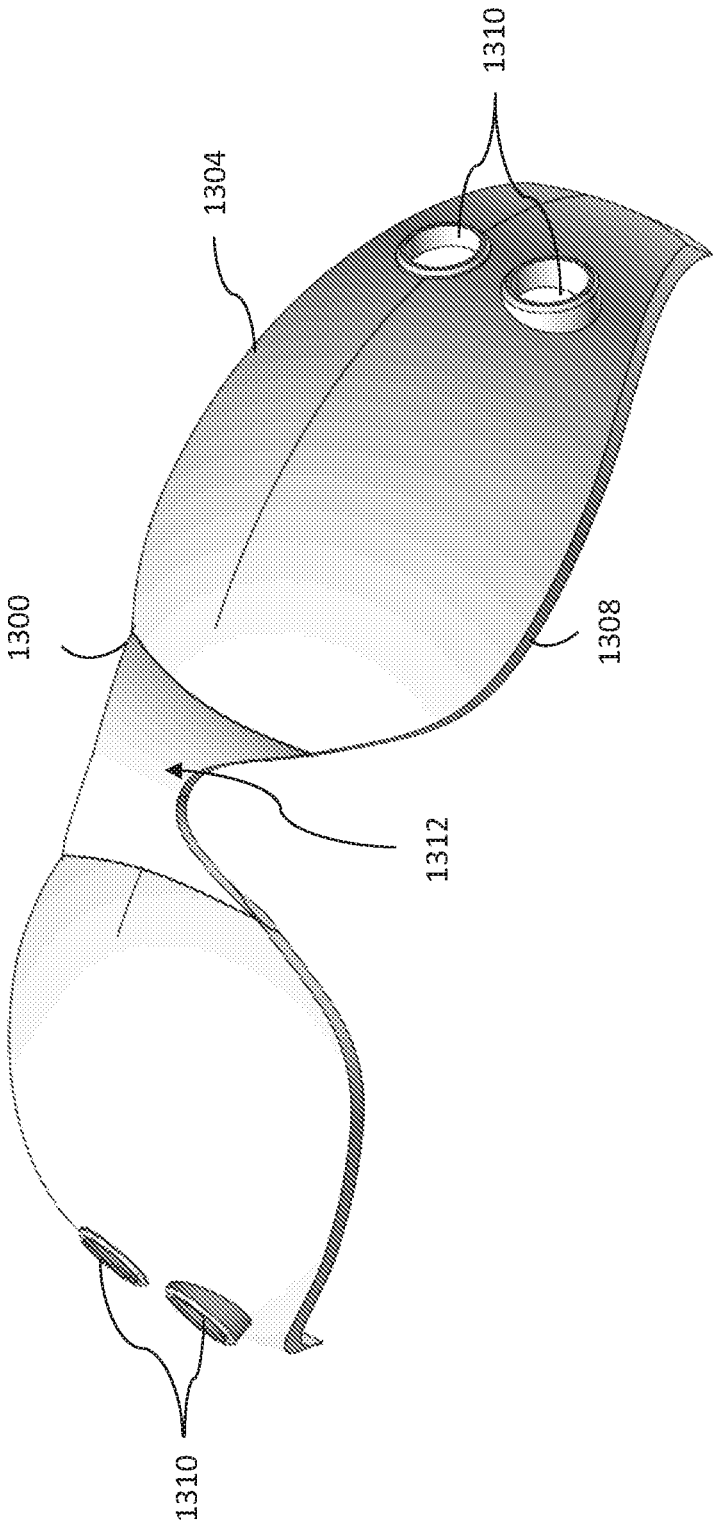


FIG. 48B

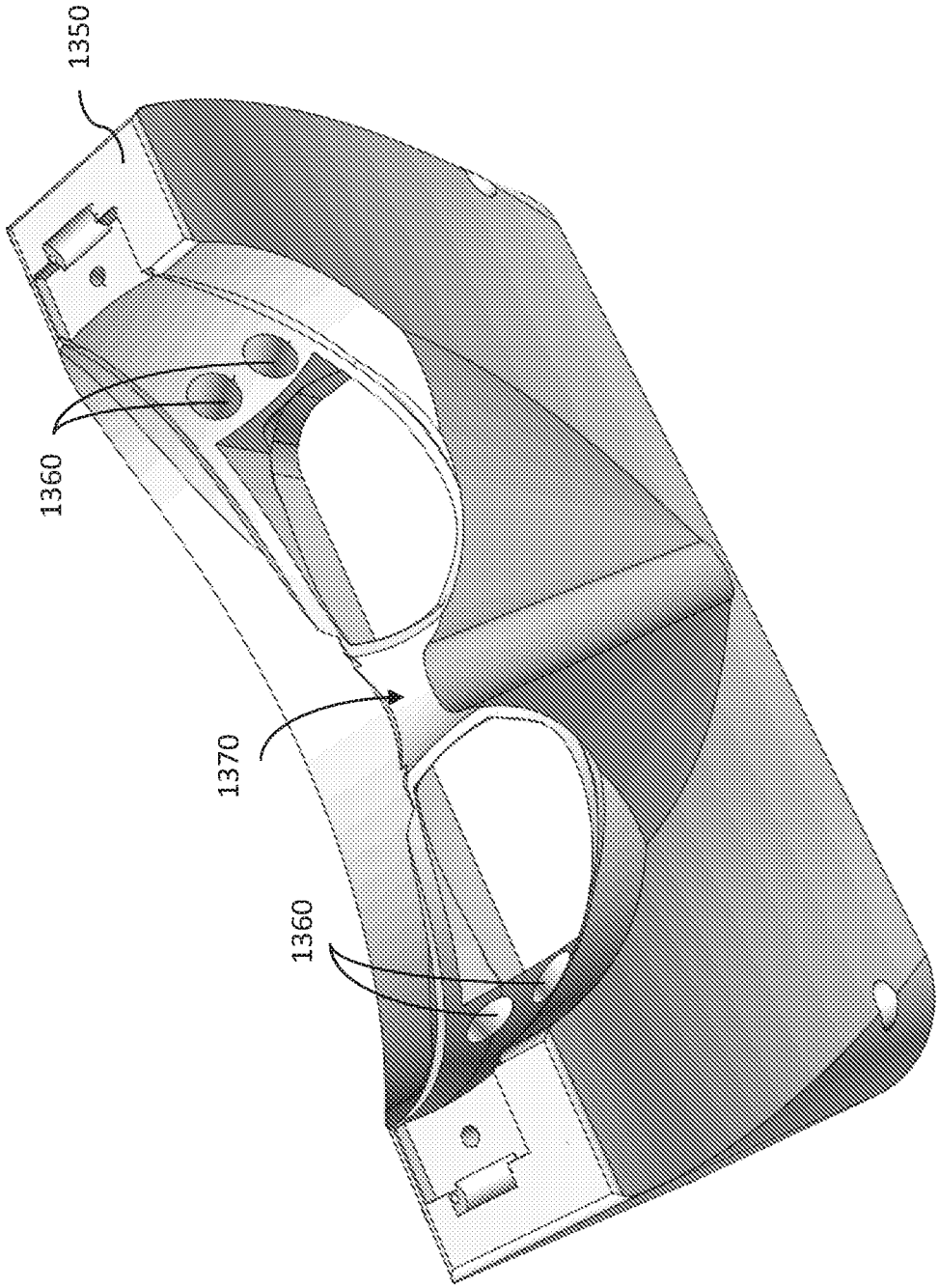


FIG. 48C

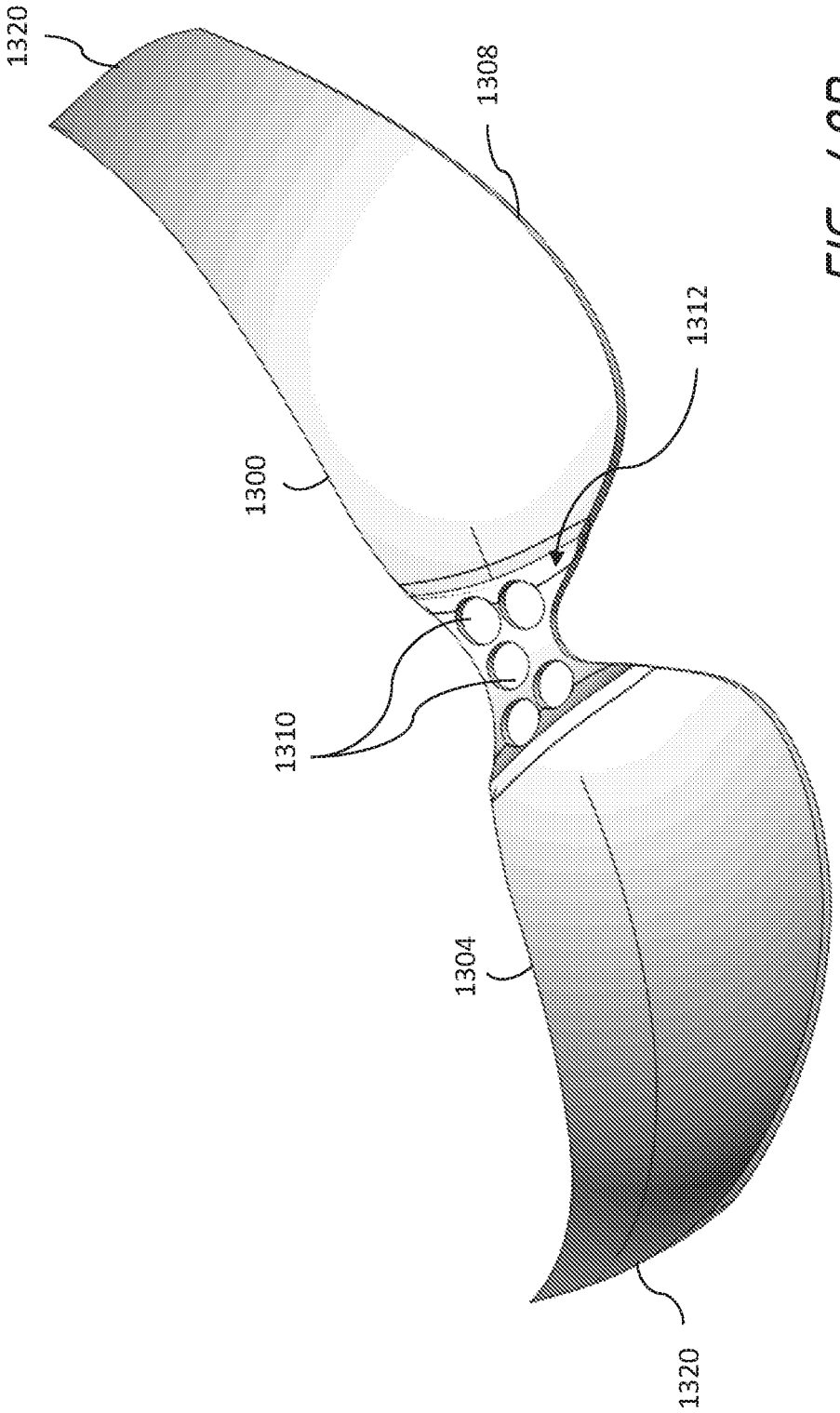


FIG. 48D

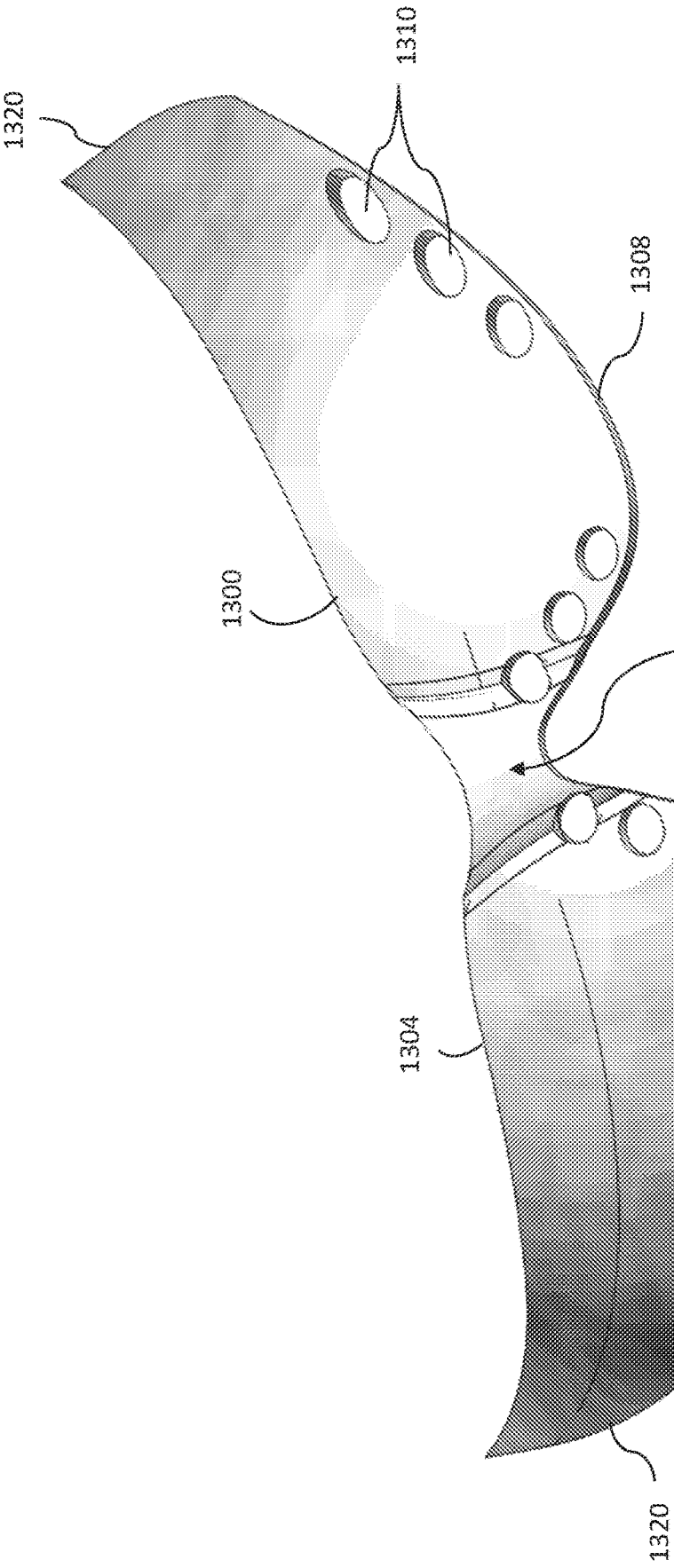


FIG. 48E

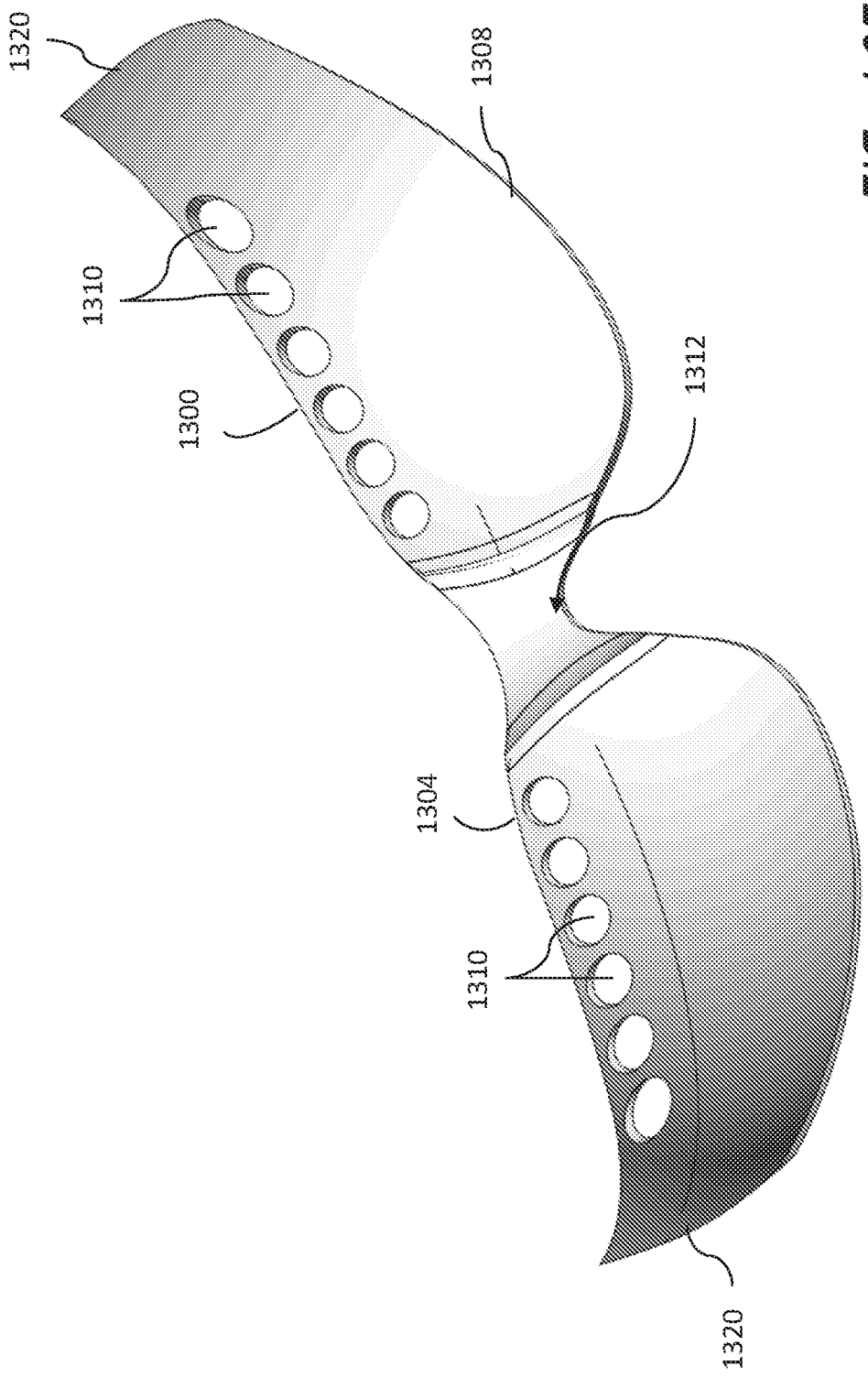


FIG. 48F

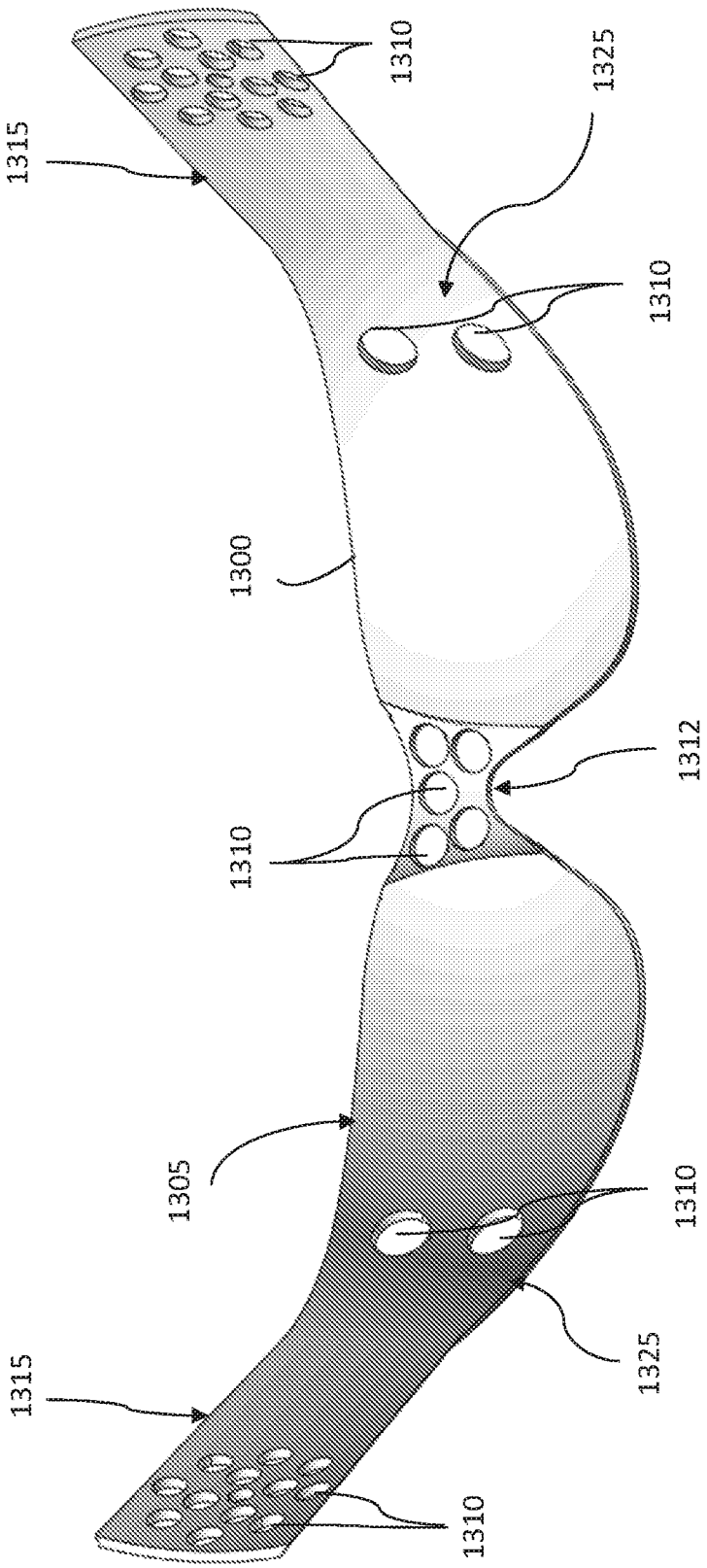


FIG. 48G

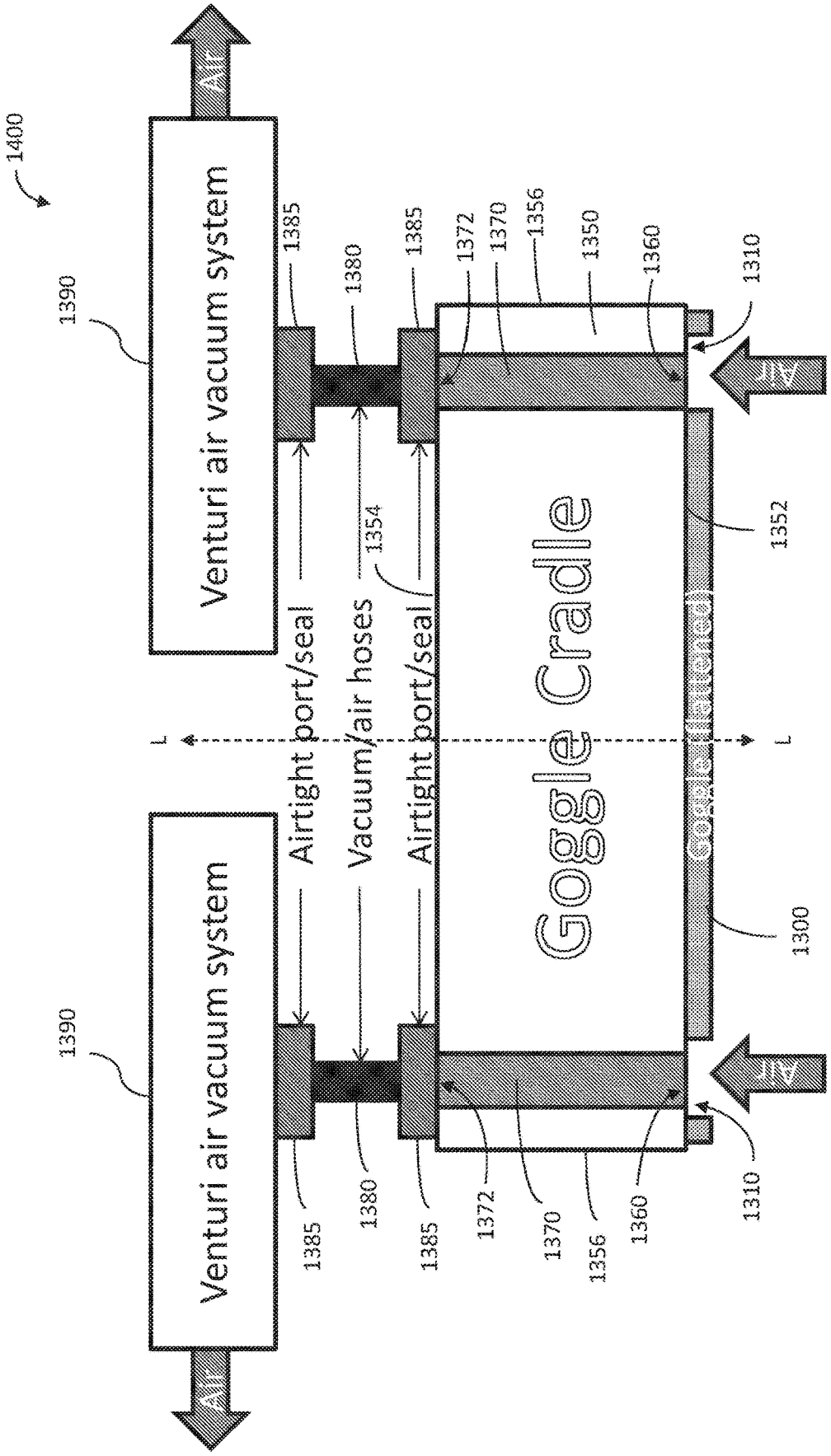

1400
1390
Venturi air vacuum system
Air
1385
1380
1385
1372
1370
1356
1350
1360
1310
Air
Airtight port/seal
Vacuum/air hoses
Airtight port/seal
1354
Goggle Cradle
Conductive Element
1352
1300
L
L
1390
Venturi air vacuum system
Air
1385
1380
1385
1372
1370
1356
1360
1310
Air

FIG. 49

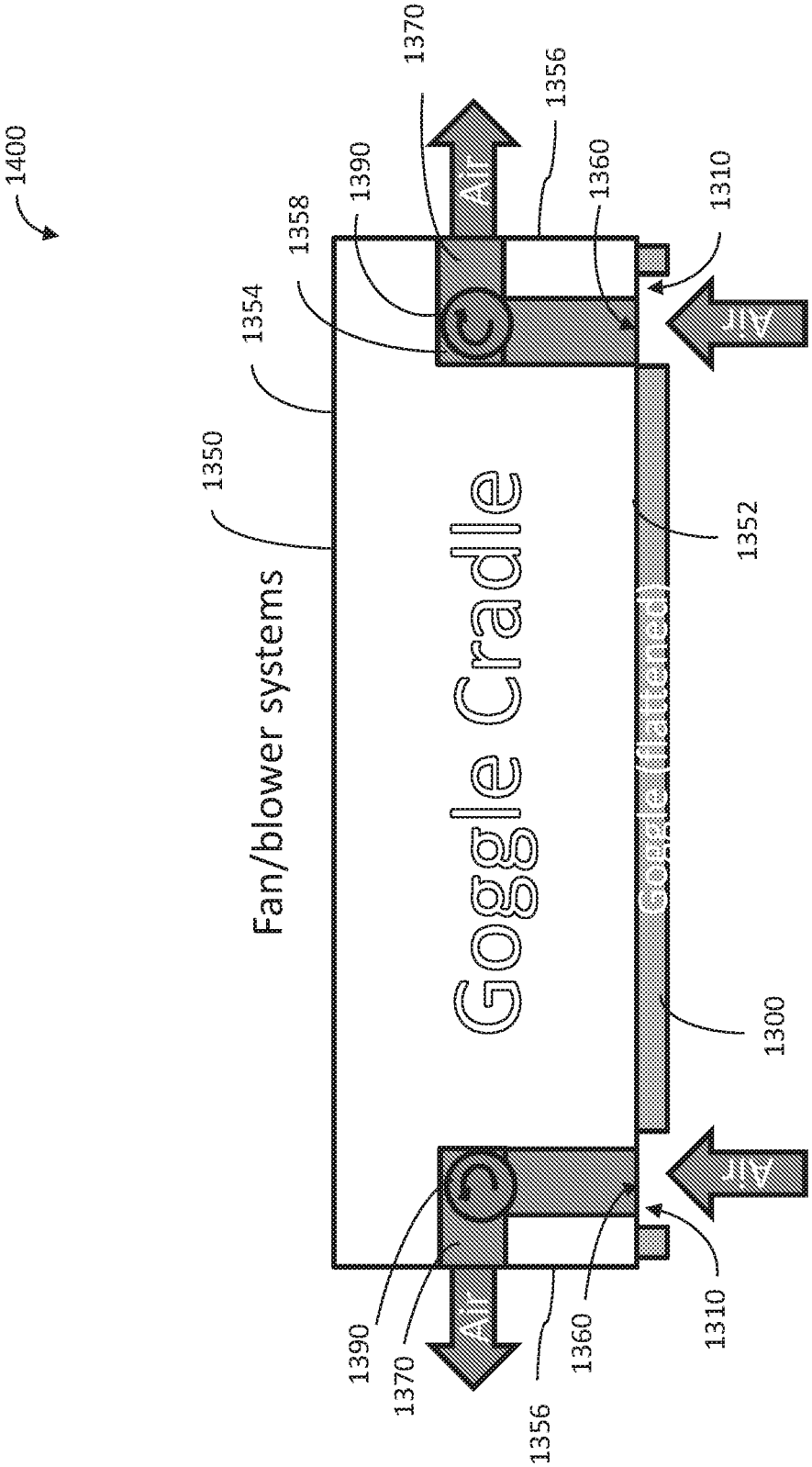

1400
1370
1356
1390
1360
1310
1358
1354
1350
Air
Air
Air
Air
Goggle Cradle
Fan/blower systems
Gender (Universal)
1352
1300
1390
1370
1356
1360
1310

FIG. 50

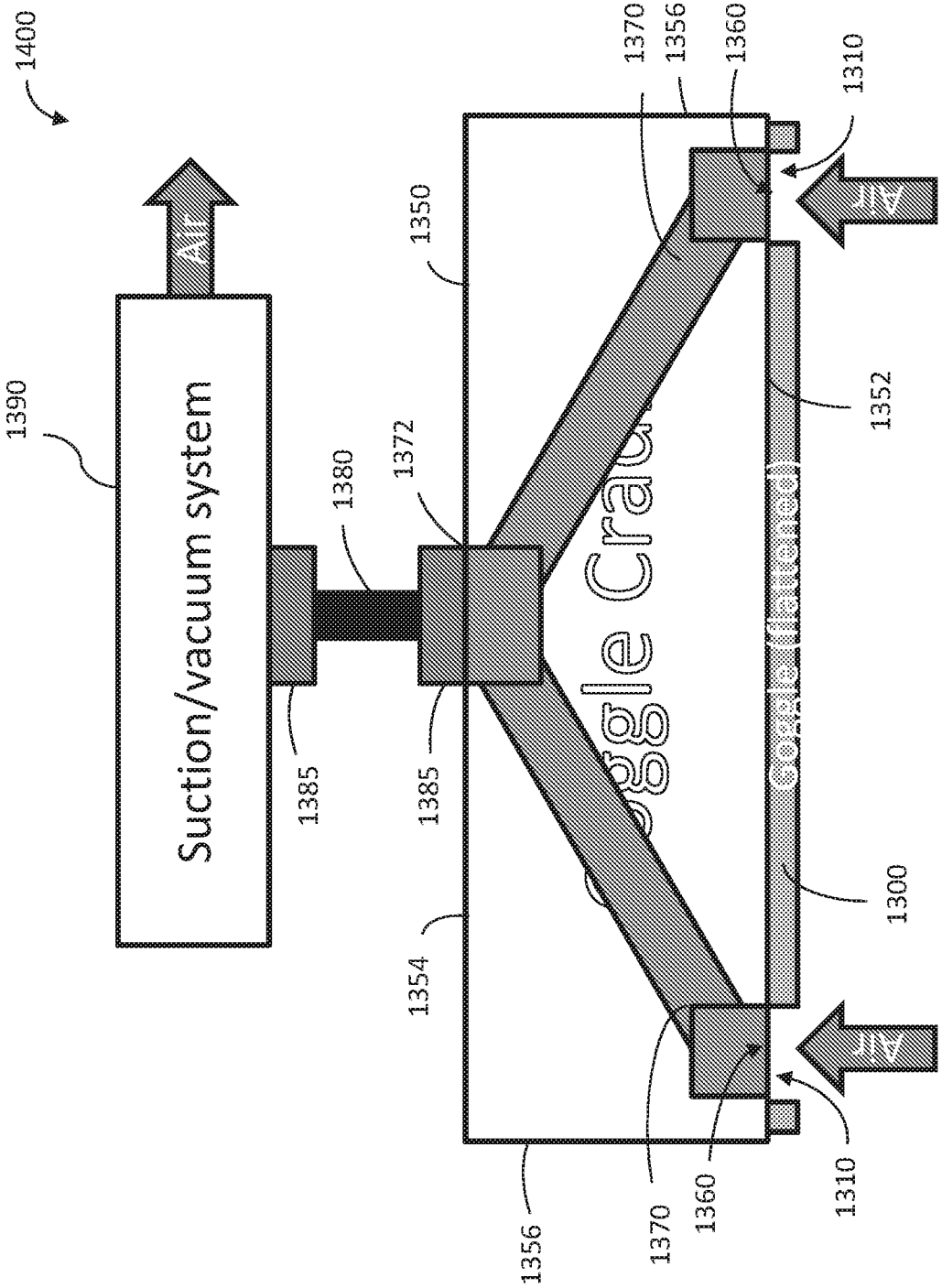

1400
Air
1390
Suction/vacuum system
1385
1380
1372
1385
1350
1370
1356
1360
1310
Air
1352
Toggle Crawler (Inverted)
1300
1354
Air
1356
1370
1360
1310

FIG. 51

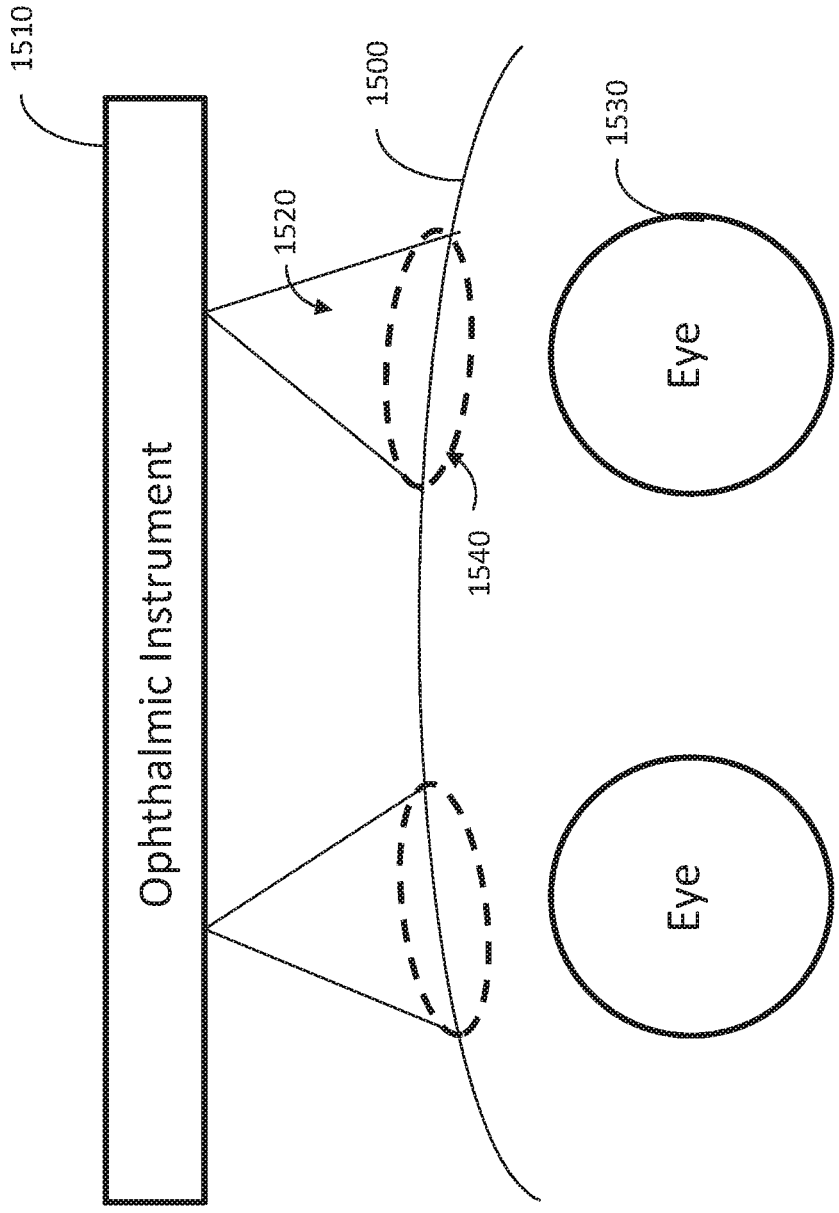


FIG. 52

MEDICAL INTERFACES AND OTHER MEDICAL DEVICES, SYSTEMS, AND METHODS FOR PERFORMING EYE EXAMS

RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 15/761,077, filed Mar. 16, 2018, which is a U.S. national phase entry of PCT Application No. PCT/US2016/051778, filed Sep. 14, 2016, which claims the benefit of U.S. Provisional Application No. 62/220,866, filed Sep. 18, 2015, U.S. Provisional Application No. 62/220,194, filed Sep. 17, 2015, and U.S. Provisional Application No. 62/330,057, filed Apr. 30, 2016. The present application is a continuation-in-part of U.S. application Ser. No. 16/985,704, filed Aug. 5, 2020, which is a continuation of U.S. patent application Ser. No. 14/852,379, filed Sep. 11, 2015, now U.S. Pat. No. 10,772,497, which claims priority benefit under 37 C.F.R. 119(e) to U.S. Provisional Patent Application No. 62/051,237, filed Sep. 16, 2014, U.S. Provisional Patent Application No. 62/050,034, filed Sep. 12, 2014, as well as U.S. Provisional Patent Application No. 62/050,676, filed Sep. 15, 2014. The present application is a continuation-in-part of U.S. application Ser. No. 16/828,840, filed Mar. 24, 2020, which is a continuation of Ser. No. 14/984,035, filed Dec. 30, 2015, now U.S. Pat. No. 10,631,725, which is a continuation of Ser. No. 13/802,727, filed Mar. 14, 2013, now U.S. Pat. No. 9,226,856. Each of these above-referenced applications is incorporated herein by reference in their entirety.

BACKGROUND

Field

Embodiments of the present disclosure relate to the field of healthcare, including for example, devices, systems, methods of automating the provision of diagnostic healthcare services to a patient as part of an examination meant to detect disorders or diseases. In some but not all instances, these healthcare services may apply only to eye care encounters, exams, services and eye diseases.

Description of the Related Art

Many people visiting medical offices often use the same equipment. Cross-contamination has become a problem of increasing concern, especially during certain periods such as flu season. As the provision of healthcare becomes more automated, fewer office personnel may be present to clean devices between uses. Accordingly, systems and methods for improving hygiene are desirable.

SUMMARY

A wide range of embodiments are described herein. In some embodiments, a mask may comprise a distal sheet member having one or more substantially optically transparent sections and a proximal inflatable member having a rear concaved surface that may face a first patient's face when in use. The rear concaved surface may be configured to conform to contours of the first patient's face. The inflatable member may have two cavities therein. The two cavities may be generally aligned with the one or more substantially optically transparent sections, and may extend from the rear concaved surface toward the distal sheet member such that the cavities define two openings on the rear concave surface. The rear concave surface may be configured to seal against the first patient's face such that the first patient's eyes align with the two cavities, so that the rear concave surface forms seals around a peripheral region of the first patient's eye sockets that inhibit flow of fluid into and out of the cavities. The mask may further comprise an ocular port providing access to at least one of the two ocular cavities for fluid flow into and out of the at least one of the two ocular cavities and an inflation port providing access to inflate the inflatable member.

In various embodiments, the rear concaved surface may be configured to conform to the contours of the first patient's face with inflation of the inflatable member via the inflation port. The inflatable member may be underinflated and the rear concaved surface may be configured to conform to the contours of the first patient's face with inflation of the underinflated inflatable member via the inflation port. The rear concaved surface may be configured to conform to the contours of the first patient's face with application of negative pressure to the inflatable member via the inflation port. The mask may further comprise particulate matter disposed within the inflatable member. The particulate matter may be configured to pack together with application of a negative pressure to the inflatable member via the inflation port, so that the rear concaved surface conforms to the contours of the first patient's face.

In various embodiments, the rear concaved surface may be configured to conform to contours of a second patient's face, wherein a contour of the second patient's face is different from a contour of the first patient's face. The seals may be air-tight. The mask may further comprise a lip extending into at least one of the two cavities from a perimeter of at least one of the two openings, the lip having distal ends curving toward the distal sheet member in a default position, the distal ends configured to move rearwardly such that the lip seals against the user's face upon introduction of positive pressure into the at least one of the two cavities. The inflatable member may be opaque.

In various embodiments, the distal sheet may be configured to interface with a medical device, which may be an eye exam device. The mask may be configured to couple with a docking portion on a medical device. The mask may be configured to couple with the docking portion via a flange that slides into a slot of the docking portion. The inflation port and the ocular port of the mask may be configured to couple with conduit ends on a medical device. The ocular port and the inflation port may include a male portion, wherein the conduit ends on the medical device include a female portion configured to slidably receive the male portion. The ocular port and the inflation port may be configured to couple with the conduit ends on the medical device substantially simultaneously.

Some embodiments relate to the utilization of devices that replace, augment, or enhance human laborers in a clinical health care setting. These devices may be used alone or in conjunction with other devices used in exams such as exams of the eye.

For purposes of this summary, certain aspects, advantages, and novel features of the invention are described herein. It is to be understood that not necessarily all such aspects, advantages, and features may be employed and/or achieved in accordance with any particular embodiment of the invention. Thus, for example, those skilled in the art will recognize that the invention may be embodied or carried out in a manner that achieves one advantage or group of advantages as taught herein without necessarily achieving other advantages as may be taught or suggested herein.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other features, aspects and advantages of the present invention are described in detail below with reference to the drawings of various embodiments, which are intended to illustrate and not to limit the invention. The drawings comprise the following figures in which:

FIG. **1** schematically illustrates a perspective view of one embodiment of a mask, which is inflatable and includes a framework that forms two cavities for the oculars.

FIGS. **2**A-**2**B schematically illustrates a mask removably attached to a medical device.

FIG. **3** schematically illustrates a user wearing a mask that provides, for example, an interface to a medical device such as a diagnostic device that is used by many patients.

FIG. **4** schematically illustrates a perspective view of another embodiment of a mask with an inflatable framework that is partitioned into two separately inflatable sections.

FIG. **5** schematically illustrates a cross section of the mask in FIG. **4** taken along the lines **5**-**5**.

FIG. **6** schematically illustrates a perspective view of another embodiment of a mask with a seal around the ocular cavities.

FIG. **7***a* schematically illustrates a side view of one embodiment of a mask displaced a first distance from a medical device.

FIG. **7***b* schematically illustrates a side view of another embodiment of a mask displaced a second distance from the medical device.

FIG. **8** schematically illustrates a schematic diagram of a system for controlling, monitoring, and providing fluid to a mask.

FIG. **9** schematically illustrates a schematic diagram an electronic exam portal.

FIG. **10** schematically illustrates a healthcare office map.

FIG. **11** schematically illustrates a block diagram of a sample healthcare encounter.

FIG. **12** schematically illustrates a binocular eye examination system based on optical coherence tomography.

FIG. **13** schematically illustrates a display of eye examination data.

FIGS. **14**A-D schematically illustrate a mask having optically transparent sections that are tilted or sloped upward or downward and include an anti-reflection (AR) coating to reduce retro-reflection of light from an incident probe beam from an optical coherence tomography instrument back into the instrument.

FIGS. **15**A and **15**B schematically illustrate the effect of a tilted or sloped window on a probe beam from the OCT instrument, which reduces retro-reflection into the optical coherence tomography instrument.

FIGS. **15**C-E schematically illustrate the effect of a tilted or sloped window on a mask on the light reflected from an incident OCT probe beam and how tilting or sloping the window beyond the angle of the steepest ray of light from the probe beam can reduce retro-reflection into the optical coherence tomography instrument.

FIGS. **16**A-D schematically illustrate a mask having optically transparent sections that are tilted or sloped nasally or temporally to reduce retro-reflection of light from an incident probe beam back into the optical coherence tomography instrument.

FIGS. **17**A-E schematically illustrate a curved window on a mask and demonstrates how the location of the window with respect to the focus of the OCT instrument (e.g., oculars or eyepieces) can vary the amount of retro-reflection of light from the optical coherence tomography instrument back into the OCT instrument.

FIGS. **18**A-D schematically illustrate a mask having optically transparent sections that are curved to reduce retro-reflection of light from the optical coherence tomography instrument back into the OCT instrument.

FIG. **19** schematically illustrate a curved window on a mask disposed forward of a pair of eyes separated by an interpupillary distance wherein the window is increasing sloped more temporal from a center line through the window thereby exhibiting wrap that reduces retro-reflection of light from the optical coherence tomography instrument back into the OCT instrument.

FIGS. **20**A-D schematically illustrate a mask having an optical window having wrap as well as curvature in the superior-inferior meridian to reduce retro-reflection of light from the optical coherence tomography instrument back into the OCT instrument.

FIGS. **21**A-**27** and **29**A-C schematically illustrate differently shaped mask windows.

FIGS. **28**A-D schematically illustrate design considerations in determining the slope of the window at different distances from the centerline through the mask.

FIG. **30**A illustrates an embodiment of a receptacle for receiving a mask to be worn by a subject.

FIG. **30**B illustrates receptacle mask attached to the contoured receptacle of FIG. **30**A.

FIG. **30**C illustrates an embodiment of a contoured receptacle having a forehead shield and a nose shield.

FIG. **31** illustrates a mask attached to a contoured receptacle.

FIGS. **32**A-**32**C illustrate a method of attaching a mask to the contoured receptacle shown in FIG. **30**A.

FIGS. **33**A-**33**C illustrate a method of attaching a mask to another embodiment of the contoured receptacle.

FIGS. **34**A-**34**C illustrate a method of attaching a mask to another embodiment of the contoured receptacle.

FIGS. **35**A and **35**B illustrate a method of attaching a mask to yet another contoured receptacle.

FIGS. **36**A and **36**B illustrate a user's head entering into a mask.

FIG. **37** illustrate a user's head in another embodiment of the mask.

FIG. **38** illustrates a contoured receptacle and mask constraining movement of a user's head.

FIGS. **39**A-**39**D illustrate an embodiment of a mask.

FIGS. **40**A-**40**D illustrate another embodiment of a mask.

FIGS. **41**A-**41**D illustrate the mask shown in FIGS. **40**A-**40**D attached to a contoured receptacle.

FIGS. **42**A-**42**D illustrate the mask and contoured receptacle shown in FIGS. **41**A-**41**D and a deformable portion.

FIGS. **43**A-**43**C illustrate a method of inserting the mask assembly shown in FIGS. **42**A-**42**D into an OCT device.

FIG. **44** is a flow chart of a method of using an interlock mechanism.

FIGS. **44**A-**44**D schematically illustrate a method of using an interlock mechanism.

FIG. **45** illustrates another embodiment of the mask attached to the contoured receptacle.

FIGS. **46**A and **46**B illustrate a mask assembly having a mask and a deformable portion.

FIGS. **47**A and **47**B illustrate a mask assembly having a mask, a contoured portion, and a deformable portion.

FIG. **48**A illustrates a posterior surface of an embodiment of a mask with a plurality of apertures for venting.

FIG. **48**B illustrates an anterior surface of the mask shown in FIG. **48**A.

FIG. **48**C illustrates a cradle portion configured to interface with the mask shown in FIGS. **48**A and **48**B.

FIG. **48**D illustrates a posterior surface of another embodiment of a mask with a plurality of apertures for venting.

FIG. **48**E illustrates a posterior surface of yet another embodiment of a mask with a plurality of apertures for venting.

FIG. **48**F illustrates a posterior surface of yet another embodiment of a mask with a plurality of apertures for venting.

FIG. **48**G illustrates a posterior surface of yet another embodiment of a mask with a plurality of apertures for venting.

FIG. **49** is a schematic representation of an embodiment of a cradle portion.

FIG. **50** is a schematic representation of another embodiment of a cradle portion.

FIG. **51** is a schematic representation of yet another embodiment of a cradle portion.

FIG. **52** is a schematic illustration of a hygienic barrier.

DETAILED DESCRIPTION

Some embodiments disclosed herein provide an inflatable mask that can interface with medical devices, such as medical diagnostic devices, such as optical coherence tomography ("OCT") devices. The inflatable mask can serve a variety of purposes, including maintaining a barrier between the patient and the medical device to ensure cleanliness and hygiene, providing comfort to the patient, and stabilizing the patient's location with respect to the machine. In some embodiments, the inflatable mask can form air-tight ocular cavities around the patient's eyes, allowing for pressurization of the ocular cavities, in order to obtain ocular measurements. Additionally, various embodiments of an automatic portal system and an automated eye examination are disclosed herein.

Embodiments of the invention will now be described with reference to the accompanying figures, wherein like numerals refer to like elements throughout. The terminology used in the description presented herein is not intended to be interpreted in any limited or restrictive manner, simply because it is being utilized in conjunction with a detailed description of certain specific embodiments of the invention. Furthermore, embodiments of the invention may comprise several novel features, no single one of which is solely responsible for its desirable attributes or which is essential to practicing the embodiments of the inventions herein described.

Inflatable Medical Interface

Referring to FIG. **1**, in one embodiment, a mask **100** includes a distal sheet member (distal portion) **118** which has optically transparent sections **124**, and a proximal inflatable member (proximal portion) **154** having a generally concaved rear surface **122**. In use, the rear concaved surface **122** faces the patient's face and conforms to the patient's face, according to some embodiments. As used herein the terms "user" or "patient" or "subject" or "wearer" may be used interchangeably. Still Referring to FIG. **1**, the inflatable member **154** can have two cavities **160***a*, **160***b* which are aligned with the optically transparent sections **124**. In some embodiments, the cavities **160***a*, **160***b* extend from a distal sheet **118** to the rear concave surface **122** and define two openings **162** on the rear concave surface **122**. In use, the patient's eyes align with the two cavities **160***a*, **160***b*, so that the rear concave surface **122** forms seals around the patient's eye sockets or face, e.g. forehead and cheeks, inhibiting flow of fluid into and out of the cavities **160***a*, **160***b*. In addition, the mask **100** can include ports **170***a-b*, **180***a-b* which provide access to control flow of fluid (e.g. air) into and out of the cavities **160***a*, **160***b*.

In some embodiments, the mask **100** can interface with a medical device. With reference to FIGS. **2***a*-**2***b*, there is illustrated one embodiment whereby the mask **100** is placed on a separate device **112**. In some embodiments, the separate device **112** is a medical device, such as a diagnostic or therapeutic device. In some embodiments, the separate device **112** is an ophthalmic device, such as a device for the eye, and may be an optical coherence tomography device ("OCT") that may contain a housing and instrumentation contained therein. The mask **100** may be used with a wide range of medical devices **112**, such as for example an OCT device such as disclosed herein, as well as other OCT devices and other medical devices **112**. In some embodiments, the medical device **112** can receive and removably connect to the mask **100**. The mask **100** can be configured to connect to the medical device **112**, adhere to one or more surfaces of the medical device **112**, or be mechanically fixed to the medical device **112**, or be secured to the medical device **112** in any other way (e.g. clamps, straps, pins, screws, hinges, elastic bands, buttons, etc.), such that the mask **100** is removable from the medical device **112** without damaging the mask **100**.

In one embodiment, a docking portion **114**, which may include an optical interface such as for example a plate, can be included on the medical device **112**. The docking portion **114** can also include a slot **116** for receiving a mask **100**. In some embodiments, the mask **100** includes a flange **164** that extends laterally outward past a side of the inflatable member **154** on the distal sheet **118** for slidably engaging with the slot **116**. The mask **100** can be inserted into the slot **116** and slide down to a final locking position **120**. In another embodiment, the flange **164** can be on the medical device **112** and the slot **116** can be on the mask **100**.

With reference to FIG. **3**, there is illustrated an example of a mask **100** worn by a user over the user's eyes. In various embodiments, the mask **100** may be removably attached to the wearer with an adhesive, an elastic band, a Velcro band, a strap, a buckle, a clip, and/or any other suitable fastener or mechanism. In some embodiments, the mask **100** can include mechanisms for both attaching to the wearer and attaching to the medical device **112**. In other embodiments, a patient may use the mask **100** without any straps, bands, etc. that attach to the user. For example, referring to FIGS. **2***a-b*, the patient may simply move his/her face in alignment and in contact with the mask **100**, which is secured to the medical device **112**. In another embodiment, a patient who has a mask **100** secured to his/her face may position himself/herself properly with respect to the medical device **112**, so that the distal sheet **118** interfaces with the medical device, **112**, and the medical device **112** can take readings.

Returning to FIG. **1**, one embodiment of the mask **100** comprises an inflatable framework **154** having an inflatable chamber **154***a*, two cavities **160***a*, **160***b*, a frontward surface formed by a distal sheet member **118**, and a rearward surface **122**. It will be understood that "inflatable," as used herein, can include "deflatable," and vice versa. Thus, in some embodiments, an "inflatable" framework **154** or chamber **154***a* can be deflatable, and a "deflatable" framework **154** or chamber **154***a* can be inflatable. Referring to FIG. **1**, cavities **160***a*, **160***b* may extend between the distal sheet member **118**

and the rearward surface **122**. In some embodiments, the frontward member **118** includes a window member **124**, which can be substantially optically transparent in some embodiments, with minimal to no effects on the optics of a medical device **112** (e.g. an OCT device) which can interface with the mask **100**, although some embodiments may introduce optical effects. In some embodiments, the distal sheet member **118** can be rigid. In some embodiments, the distal sheet member **118** can be made of polycarbonate, poly (methyl methacrylate), or glass. Other materials can be used. In other embodiments, the distal sheet member **118** can be flexible. The distal sheet member **118** can have a thickness of less than 0.1 mm, 0.1 mm, 0.5 mm, 1 mm, 2 mm, 4 mm, or more. In one embodiment, the window member **124** may be adjacent to the inflatable framework **154**. Thus, the window member **124** may form a frontward surface of a cavity **160***a*, **160***b*. Further, the window member **124** may be aligned with the cavities **160***a*, **160***b*. In addition, the cavities **160***a*, **160***b* can define openings on the rearward surface, defined by perimeters **162**. Referring to FIG. **4**, the inflatable framework **154** can have two separately inflatable chambers **150***a*, **150***b*. Still referring to FIG. **4**, in one embodiment, one inflatable chamber **150***a* can have a cavity **160***a* therein, and another inflatable chamber **150***b* can have another cavity **160***b* therein.

The distal sheet member **118** may be substantially flat and the rearward surface **122** may be generally curved and concave according to one embodiment. Referring to FIG. **4**, in one embodiment the thickness of the mask **100** is thinnest at the center **156** and thickest toward the outer edges **158**, with the thickness decreasing from the outer edges **158** toward the center **156**, thereby defining a curved and concave rearward surface **122**.

During use, a patient's face is brought in contact with the rearward surface **122** of the mask, such that the patient's eyes are aligned with the cavities **160***a*, **160***b*, and the patient "sees" into the cavities **160***a*, **160***b*. Thus in some embodiments, the cavities **160***a*, **160***b* may be referred to as ocular cavities **160***a*, **160***b*. In one embodiment, only the portion of the distal sheet member **118** that aligns with the patient's eyes may be optically transparent, with other portions opaque or non-transparent.

In some embodiments, the rear concaved surface **122** of the mask **100** can seal against a patient's face around the general area surrounding the patient's eyes sockets, thereby forming a seal around the patient's eye sockets. The seal may be air-tight and liquid-tight according to some embodiments. In some embodiments, a seal may be formed between the user and the mask **100** without the need for assistance from additional personnel. In some embodiments, various portions of the patient's face can form the seal around the ocular cavities **160***a*, **160***b*. For example, the patient's forehead, cheekbones, and/or nasal bridge (e.g. frontal bone, supraorbital foramen, zygomatic bone, maxilla, or nasal bone) can form a seal around the ocular cavities **160***a*, **160***b*. As used herein, reference to a "peripheral region" around the eye socket shall refer to any combination of the above.

FIG. **5** illustrates a top view of a patient wearing a mask **100**. The mask **100** in FIG. **5** is a cross-section of the mask **100** taken along line **5-5** in FIG. **4**. Referring to FIG. **5**, as seen from the view of the patient, the mask **100** comprises a right cavity **160***b*, such as a right ocular right cavity, a left cavity **160***a*, such as a left ocular cavity, a right inflatable chamber **150***b*, and a left inflatable chamber **150***b*. The walls **172** of the ocular cavities **160***a*, **160***b*, the window members **124**, and the head of the user **195** may form an air-tight enclosed area. The head of the user **195** (e.g. the peripheral region around the user's eye sockets) forms a seal with the rearward perimeters **162** of the cavities **160***a*, **160***b*, thus allowing the cavities **160***a*, **160***b* to hold air or fluid. This seal may be capable of holding air or fluid pressures of, for example, 0.5 psi, 1 psi, or 5 psi or pressures therebetween. Higher or lower pressures are also possible.

Still referring to FIG. **5**, some embodiments include inlet assemblies **155***a*, **155***b*. The inlet assemblies may include ports **170***a-b*, **180***a-b*, allowing access to the inflatable chambers **150***a*, **150***b*, and/or the cavities **160***a*, **160***b*.

Air, fluid, and/or other substances can be introduced into the ocular cavities **160***a*, **160***b*, via ports **180***a*, **180***b*, **185***a*, **185***b*. Air may be introduced into the left ocular cavity **160***a* by supplying an air source (e.g. via a pump) to the port at **180***a*. Thus, following the path of the air, the air may enter the port at **180***a*, then exit the port at **185***a* and into the left ocular cavity **160***a* (**180***a* and **185***b* represent two ends of the same path). Similarly, regarding the right ocular cavity **160***b*, air may enter the port at **180***b*, and then exit the port at **185***b* and into the right ocular cavity **160***b*.

Accordingly, in some embodiments, pressure inside the ocular cavities **160***a*, **160***b* may be controlled by adjusting the amount of air into and out of the ports **180***a*, **180***b*. Further, the air tight seal formed between the patient's face and the mask **100** can prevent unwanted leaks into or out of the ocular cavities **160***a*, **160***b*. This can be advantageous when air or fluid is used to challenge or test a body function. For example, air pumped into sealed air chamber cavities **160***a*, **160***b* in front of the eye can create positive pressure, which can be used to press on the eye for the purposes of measuring the force of globe retropulsion or measuring intraocular pressure. In addition, air can be directed to the cornea, which is imaged with OCT. In some embodiments, air is pumped into the ocular cavities **160***a*, **160***b* to achieve a pressure of up to 1-2 psi. In some embodiments, the air supplied to the ocular cavities **160***a*, **160***b* is supplied by ambient surroundings, such as the ambient air in a clinical room using for example a pump.

In some embodiments, chamber ports **170***a*, **170***b*, **175***a*, **175***b* provide access to inflatable chambers **150***a*, **150***b* for inflating or deflating the chambers **150***a*, **150***b*. The chambers **150***a*, **150***b* may be inflated by introducing an air source (e.g. via a pump) to the ports at **170***a*, **180***a*. Thus, for example, following the path of the air, the air may enter the port at **170***a*, then exit the port at **175***a* and into the left inflatable chamber **150***a*, thereby inflating that chamber **150***a*. The right chamber **150***b* may be inflated in a similar manner. Negative pressure (e.g. a vacuum) can be applied to the ports **170***a*, **170***b* connected to the inflatable chambers **150***a*, **150***b*, thereby deflating the chambers **150***a*, **150***b*. As used herein, "deflating" shall include applying negative pressure.

In some embodiments, inflating the chambers **150***a*, **150***b* can cause the mask **100** to conform to the contours of a user's face. In addition, deflating the chambers **150***a*, **150***b* can cause the mask **100** to conform to the contours of a user's face. Further, inflating or deflating the chambers **150***a*, **150***b* can adjust a thickness of the mask **100**, thus changing the distance between a user (who may face the rear concaved surface **122**) and a medical device **112** (which may be interfaced with the distal sheet member **118**).

In various embodiments, a port **170***a-b*, **180***a-b* is provided for each chamber **150***a*, **150***b* and cavity **160***a*, **160***b*. For example, referring to FIG. **5**, there is illustrated a port **185***b* for the right cavity, a port **175***b* for the right inflatable chamber **150***b*, a port **185***a* for the left cavity **160***a*, and a port **175***a* for the left inflatable chamber **150***a*.

In one embodiment, two ports may be provided for one inflatable framework **154**. For example, returning to FIG. **1**, one port **170***b* is provided on the right side of the inflatable framework **154**, and another port **170***a* is provided on the left side of the inflatable framework **154**. Providing two ports for one chamber **154** can help to equalize the distribution of substances (e.g. air or fluid) in the chamber **154** by allowing access to the chamber **154** at different regions. In one embodiment, the inflatable framework **154** does not include any ports. For example, the inflatable framework **154** may be pre-formed as desired, by filling it with a desired volume of fluid or air. Ports **170***a-b*, **180***a-b* may be added, removed, arranged, or configured in any suitable manner.

In some embodiments, the mask **100** advantageously can conform to a patient's face, thereby allowing the formation of a complete air-tight seal between the peripheral region around a user's eye sockets and the rear concaved surface **122** around the ocular cavities **160***a*, **160***b*. Accordingly, the rearward perimeter **162** of the cavities **160***a*, **160***b* can be configured to sealingly engage a periphery of a patient's eye socket. In some embodiments, the mask **100** includes a recess **168** (see e.g. FIGS. **1**, **4**, **6**), allowing room for a patient's nose, so that the mask **100** forms a seal against the parts of a patient's face with a lower degree of curvature, increasing the surface area of the patient's face to which the mask **100** conforms.

In one embodiment, the air-tight seal can be formed by inflating the inflatable framework **154**. In some embodiments, the inflatable framework **154** can resemble a bag. In some embodiments, a mask **100** with a relatively deflated framework **154** is provided to a patient. Because the bag **154** is deflated, it may exhibit some "slack." The patient's face may be brought in contact with the mask **100**, and then the bag **154** may be inflated, causing the bag **154** to inflate around the contours of the patient's face and thereby conform to the patient's face. Accordingly, a complete air-tight seal can be formed between the patient's face and the rear concaved surface **122** around the ocular cavities **160***a*, **160***b*. The bag **154** may be inflated by introducing air, gas, fluid, gel, or any other suitable substance. In addition, the bag **154** can be deflated, causing the mask **100** to disengage from the patient's face, according to one embodiment.

In one embodiment, an air-tight seal is formed by applying a vacuum to the inflatable framework **154**. In some embodiments, when the framework **154** is filled with particulate matter, such as coffee grounds, a plasmoid transformation to a semi-solid but form-fitting filler can be achieved by subjecting the particulate matter to a vacuum. For example, the framework **154** can be molded into shape easily when particulate matter is loosely contained in the framework **154**, similar to a bean bag. A patient's face may then be brought into contact with the mask **100**. Applying a vacuum to the bag **154** causes the particulate matter to pack tightly, thereby causing the bag **154** to conform to the contours of a patient's face. The tightly packed particulate matter can thus undergo a plasmoid transformation to a solid, while still allowing the framework **154** to conform to the patient's face and create an air-tight seal.

To facilitate the seal between a patient and the cavities **160***a*, **160***b*, the mask **100** can be configured with a lip **194** around the perimeter **162** of a cavity **160***a*, **160***b*, as illustrated in FIG. **6**. FIG. **6** illustrates a lip **194** with a cut-away portion **161** showing the curvature of the lip **194**. In one embodiment, the lip **194** comprises a first end **196** attached to the perimeter **162** of the cavity **160***a*, **160***b* and a second end **198** extending partially into the cavity **160***a*, **160***b*. In one embodiment, the edge **198** of the lip **194** may extend more or less and curl inward, as illustrated in FIG. **6**. In one embodiment, the first end **196** and second end **198** define a curve, such that the lip **194** curls inwardly partially into the cavity **160***a*, **160***b*. Further, the lip **194** can be flexible and configured to extend in a rearward direction (e.g. toward the rearward surface **122**). Thus, when pressure is introduced inside the cavity **160***a*, **160***b*, and pressure exerts a force in a rearward direction, the lip **194** can move rearwardly. When the inflatable framework **154** is sealed with a peripheral region around a user's eye socket, and the lip **194** moves rearwardly, the lip **194** can seal against the user's eye socket, preventing pressure from escaping.

In some embodiments, the mask **100** can be configured to be comfortable by filling the chambers **160***a*, **160***b* with soft gel fillers, particulate fillers such as foam beads or sand, or air fillers.

In one embodiment, the mask **100** can be custom made to fit the specific patient using it. For example, the mask **100** may be molded for a specific patient in a clinic. Thus, the mask **100** can be uniquely customized for a particular patient according to one embodiment. In another embodiment, the mask **100** is a "one size fits all" mask **100**. Other embodiments are possible, including differential sizing based on age, height, or facial structure. In some embodiments, the mask **100** is pre-inflated. In addition, air-tight seals can be formed between the rear curved surface **122** of the mask around the ocular cavities **160***a*, **160***b* and the peripheral region around a patient's eye sockets (e.g. via a lip) when the mask **100** is pre-inflated.

FIGS. **7***a*-**7***b* illustrate side views of a user with a mask **100** being examined or treated by a medical device **112** according to one embodiment.

It will be appreciated that the FIGS. **7***a*-**7***b* are schematic drawings and may possibly exaggerate the variation in size for illustrative purposes. The medical device **112** shown in FIGS. **7***a*-**7***b* can be an OCT device. Inflating the mask **100** can increase the thickness of the mask **100**, so that the mask **100** can move the patient toward or away from the device **112** when it is deflated or inflated respectively. For example, FIG. **7***a* illustrates a relatively deflated mask **100**, with a user relatively close to the device **112**. FIG. **7***b* illustrates a relatively inflated mask **100**, with the user relatively farther from the mask **100**. "Inflating" or "inflated" may include a mask **100** in a fully inflated state, or a mask **100** in a less than fully inflated state, but still in a state that is more inflated relative to a previous state (e.g. a deflated state) or at least partially inflated. Similarly, "deflating" or "deflated" may include a mask **100** in a fully deflated state, or a mask **100** in a less than fully deflated state, but still in a state that is more deflated relative to a previous state (e.g. an inflated state) or at least partially deflated.

A patient location sensor **166** can be included in order to detect how close or how far the user is from the medical device **112**. If the user is not at a desired distance from the device **112**, the framework **154** on the mask **100** can be inflated or deflated to bring the user to the desired distance. Any variety of sensors **166** can be used to detect the distance between the user and the medical device **112**, according to sensors known in the art. In one embodiment, a patient location sensor **166** can be included with the medical device **112** in alignment with the user's forehead, as illustrated in FIGS. **7***a*-**7***b*. Thus, the location sensor **166** can measure, for example, the distance or relative distance from the forehead to the medical device **112**. In one embodiment, the sensor **166** can be a switch, which can be actuated (e.g. activated or depressed) when the user's forehead presses against the switch when the user is close to the medical device **112**. In

addition, other types of sensors in different locations could measure the distance between the user and the medical device **112**. In one embodiment, the location sensor **166** is not placed on the medical device **112**, but is placed in a location that can still detect the distance between the user and the medical device **112** (e.g. on the walls of a room in which the medical device **112** is located). In one embodiment, the information regarding the distance between the user and the medical device **112** is provided by an OCT device.

FIG. **8** illustrates a system **174** for controlling, monitoring, and providing air to the inflatable mask **100**. The system **174** can be used to control a patient's distance from the medical device **112**, the patient's movement to and from the medical device **112**, the seal between the mask **100** and the patient's face, and/or pressure in the ocular cavities **160***a*, **160***b* of the mask **100**.

Referring to FIG. **8**, the system **174** can include pumps **176**, an air source **176**, conduits **178**, valves **182**, pressure sensors **188**, flow sensors **188** and/or processors (not shown). In addition, air into and out of the inflatable chambers **150***a*, **150***b* and/or cavities **160***a*, **160***b* can be controlled by similar components. Referring to FIG. **7***b*, the air source/pump **176**, valves **182**, sensors **188**, and the mask **100** can be in fluid communication with each other via conduits **178**. In addition, the air source/pump **176**, valves **182**, and sensors **188** can be in electronic communication with a processor. Further, the processor can be in communication with electronics associated with a medical device **112**, such as an OCT device.

In some embodiments, the air source/pump **176**, conduits **178**, valves **182**, sensors **188**, and processors can be contained within a single unit, such as a medical device **112**. In other embodiments, the components may be spread out across several devices external to a medical device **112**.

Referring to FIG. **8**, the mask **100** can be connected to an air source/pump **176**, which can comprise compressed air, ambient air from the environment of the mask (e.g. in a clinical room), a reservoir, a sink (e.g. for providing water to the mask **100**), an automatic pump, manual pump, hand pump, dispenser, or any other suitable air source/pump.

Valves **182** can also be included in the system **174** for increasing, decreasing, stopping, starting, changing the direction, or otherwise affecting the flow of air within the system **174**. In some embodiments, the valves **182** can direct air to an exhaust port, in order to vent air in the cavities **160***a*, **160***b* or inflatable chambers **150***a*, **150***b*. In some embodiments, valves **182** are not included in the ports **170***a-b*, **180***a-b* of the mask **100**, and are external to the mask **100**. In some embodiments, valves **182** can be included in the ports **170***a-b*, **180***a-b* of the mask **100**.

In some embodiments, the system can also include an ocular pressure sensor **186** to sense the pressure inside the ocular cavities **160***a*, **160***b*. Readings from the pressure sensor **186** can be used for intraocular pressure and retropulsion measurements. In addition, the system **174** can include a chamber pressure sensor **184**. In some embodiments, the chamber pressure sensor **184** can be used to determine whether a patient is pressing their face against the mask **100**, or how hard the patient is pressing their face against the mask **100**.

A flow sensor **188** can also be provided to measure the volume of flow into and out of the ocular cavities **160***a*, **160***b* and inflatable chambers **150***a*, **150***b*. Flow sensors **188** may be useful when, for example, the inflatable chamber **150***a*, **150***b* is underinflated such that the pressure inside the inflatable chamber equals atmospheric pressure. In such a case, pressure sensors **188** may not be useful but a flow sensor **188** can measure the volume of fluid pumped into the inflatable chamber **150***a*, **150***b*. In some embodiments, one set of sensors can be provided for the ocular cavities **160***a*, **160***b*, and another set of sensors can be provided for the inflatable chambers **150***a*, **150***b*.

Referring to FIG. **8**, the conduits **178** can convey the flow of air (or gas, liquid, gel, etc.) between the pump/air source **176**, valves **182**, sensors **188**, and the mask **100**. In some embodiments, the valves **182** can be downstream of the pump/air source **176**, the sensors **188** can be downstream of the valves **182**, and the mask **100** can be downstream of the sensors **188**.

In some embodiments, the conduit **178** terminates at conduit ends **192**, shown in FIGS. **2***a*-**2***b*. The conduit ends **192** can be designed to couple with the ports **170***a-b*, **180***a-b* of the mask **100**. Referring to FIGS. **2***a-b*, in some embodiments, the ports **170***a-b*, **180***a-b* of the mask **100** can include a male portion (e.g. a luer lock taper connector), and the conduit ends **192** can include a female portion.

In some embodiments, the ports **170***a-b*, **180***a-b* of the mask **100** can include a female portion, and the conduit ends **192** can include a male portion. In addition, the conduit ends **192** and the ports **170***a-b*, **180***a-b* can contain flanges, tubings, or any other mechanism for coupling with each other. When the ports **170***a-b*, **180***a-b* are coupled to the conduit ends **192**, an air-tight seal for fluid flow between the mask **100** and the system can be created.

Referring to FIG. **2***a*, in some embodiments, one movement (e.g. pressing the mask **100** down in the direction of the arrow **199**) can connect all four ports **170***a-b*, **180***a-b* to the conduit ends **192** at the same time. In some embodiments, the conduit ends **192** extend to the exterior of the medical device **112**, and the conduits **178** can be connected to the exterior ports **170***a-b*, **180***a-b* one at a time. In some embodiments, the conduits ends **192** are located on the medical device **112**, and a separate conduit piece can connect the conduit ends **192** to the external ports **170***a-b*, **180***a-b*.

In some embodiments, the system **174** can be used in clinical settings, such as during a medical visit (e.g. a medical examination). The components can be utilized in a variety of different ways and combinations during the medical treatment.

For example, during a medical diagnostic or treatment, referring to FIG. **2***a*, the mask **100** can be interfaced with the medical device **112** by aligning the ports **170***a-b*, **180***a-b* of the mask **100** with the conduit ends **192** in the medical device **112**, and pushing down on the mask **100**.

The patient's head can be brought into contact with the rear concaved surface **122** of the mask **100**, and system **174** can inflate or deflate the inflatable chambers **150***a*, **150***b*, so that the mask **100** conforms to the patient's face, thereby forming an air-tight seal around the ocular cavities **160***a*, **160***b*.

During the procedure, the system **174** can change the pressure in the air-tight ocular cavities **160***a*, **160***b* by a desired amount depending on the medical examination being taken. The pressure sensor **186** can sense the amount of pressure in the ocular cavities **160***a*, **160***b*, and send that data to the processor. In addition, the system **174** can vary the pressure in the ocular cavities **160***a*, **160***b* during the procedure. For example, the processor can increase the pump **176** speed or change the valve state **182** so that flow is restricted.

Other components in the medical device **112** can also take measurements, such as ocular measurements, which can be combined with the data sent by the pressure sensors. For

example, optical imaging components can measure changes in curvature or position of the anterior of the eye and in some embodiments, compare those changes to changes in the position or curvature of posterior of the eye. In addition, changes in the locations and distances of tissues, such as in the eye, can be imaged based on the pressure in cavities **160***a* and **160***b* sensed by the pressure sensors. Thus, various pieces of data can be analyzed and processed into meaningful medical information.

Further, during the procedure, the system **174** may receive data from a patient location sensor **166** (see e.g. FIGS. **7***a*-**7***b*) indicating the distance between the patient and the medical device **112**. The processor may determine that the patient should be positioned closer to or farther away from the medical device **112**, in order to obtain more accurate and precise readings. Thus, the processor may use the location of the patient to modulate the inflation or deflation of the mask **100** more or less (e.g. by changing pump speed, changing valve state, etc.), in order to bring the patient closer to or farther away from the medical device **112**.

In some embodiments, the processor can switch on the pump/air source **176** and open the valves **182** to introduce air into the ocular cavities **160***a*, **160***b* or inflatable chambers **150***a*, **150***b* according to a preset pressure or flow volume goal. In addition, flow in the system can be reversed to deflate the inflatable chambers **150***a*, **150***b*.

The mask **100** may include a mechanism for easily identifying a patient according to one embodiment. For example, the mask **100** may include an RFID tag, bar code or QR code, or other physical embodiment, to identify the wearer to other devices. Thus, for example, when a patient with a certain mask **100** nears the medical device **112**, the system can determine who the patient is, and execute instructions tailored for the patient (e.g. how much air is needed to properly inflate the framework **154**, how much pressure should be applied to the ocular cavities **160***a*, **160***b*, what readings the medical device **112** should take, etc.)

The mask **100** can be made of a material, such as plastic (e.g. polyethylene, PVC), rubber paper, or any other suitable material. In various embodiments, the mask **100** can be configured to be disposable by making it out of inexpensive materials such as paper, rubber, or plastic. In various embodiments, the mask **100** can be configured to be reusable and easily cleaned either by the wearer or by another person.

In some embodiments, the mask **100** can provide a barrier between the patient and the medical device **112**, increasing cleanliness and serving hygienic purposes.

In one embodiment, the mask **100** can be configured to create a barrier to external or ambient light, such as by constructing the mask **100** out of opaque materials that block light transmission. Accordingly, the mask **100** can prevent ambient light from interfering with medical examination measurements, such as optical devices, and ensure the integrity of those measurements.

Although examples are provided with reference to "air" (e.g. introducing air into the inflatable chamber, introducing air into the ocular cavities), it will be appreciated that other substances besides air can be used, such as gas, fluids, gel, and particulate matter.

Although examples are provided with reference to a mask **100** for a binocular system, it will be appreciated that the embodiments disclosed herein can be adapted for a monocular system. Thus, in one embodiment, the mask **100** includes an inflatable framework **154** defining one cavity instead of two, and that cavity can form a seal against the periphery of one eye socket. Further, while examples are provided with reference to eye sockets and eye examinations, it will be appreciated that the embodiments disclosed herein can be used with other tissues and medical applications.

In other embodiments, an inflatable device may cover different body tissues such as gloves for the hands, stockings for the feet or a hat for the head. In various embodiments, the inflatable device may include a cavity similar to the ocular cavity in the mask and may have at least one port to provide access to the cavity and change pressure therein or inflow gas therein or outflow gas therefrom, as well as a port to inflate the inflatable devices.

The inflatable mask can be used in a wide variety of clinical settings, including medical examinations and encounters that may be assisted by automated systems. Various embodiments of an automatic encounter portal are described below.

Electronic Encounter Portal

Medical encounters can be commonly comprised of administrative tasks, collection of examination data, analysis of exam data, and formation of an assessment and plan by the healthcare provider. In this context, a healthcare provider may be a licensed healthcare practitioner, such as a medical doctor or optometrist, allowed by law or regulation to provide healthcare services to patients. Examinations may be comprised of numerous individual tests or services that provide information for a healthcare provider to use to make a diagnosis, recommend treatment, and plan follow-up. The data from these tests that are collected for use by healthcare providers can be broken down into three rough categories: historical data, functional data, and physical data.

Historical data can be collected in many ways including as a verbal person-to-person interview, a written questionnaire read and answered by the patient, or a set of questions posed by an electronic device either verbally or visually. Typical categories of historical information that are obtained in medical exams can include but are not limited to a chief complaint, history of present illness, past medical history, past ocular history, medications, allergies, social history, occupational history, family history, sexual history and a review of systems.

Functional data can be collected through individual tests of function and can be documented with numbers, symbols, or categorical labels. Examples of general medical functions can include but are not limited to measurements of blood pressure, pulse, respiratory rate, cognitive ability, gait, and coordination. Ophthalmic functions that may be tested during an exam can include but are not limited to measurements of vision, refractive error, intraocular pressure, pupillary reactions, visual fields, ocular motility and alignment, ocular sensation, distortion testing, reading speed, contrast sensitivity, stereoacuity, and foveal suppression.

Physical data can capture the physical states of body tissues and can be collected in many forms, including imaging, descriptions or drawings, or other physical measurements. This may be accomplished with simple measurement tools such as rulers and scales. It may also be accomplished with imaging devices, such as color photography, computed tomography, magnetic resonance imaging, and optical coherence tomography (OCT). Other means to measure physical states are possible. Physical measurements in general medical exams can include height, weight, waist circumference, hair color, and organ size. Ophthalmic structural measurements can include but are not limited to slit lamp biomicroscopy, retinal OCT, exophthalmometry, biometry, and ultrasound.

Currently, almost all of the individual tests that make up a medical examination are conducted by a human laborer often through the operation of a device. Whether this person is a healthcare provider or an allied healthcare professional, these laborers can be expensive, can often produce subjective results, and can have limitations on their working capacity and efficiency. Given the labor intensive nature of exams, healthcare care practices (which may also be referred to herein as "clinics" or "offices") and in particular eye care practices often employ numerous ancillary staff members for every healthcare provider and dedicate large areas of office space for waiting rooms, diagnostic equipment rooms and exam rooms. All combined, these overhead costs make healthcare expensive, inefficient and often prone to errors.

Automation is a well-known way of improving efficiency and capacity as well as reducing unit costs. Patient-operated or entirely operator-less devices may be preferable as labor costs increase and the need for objective, reproducible, digital, quantitative data increases.

With reference to FIG. **9**, there is illustrated one embodiment of an electronic encounter portal. The encounter module **200** can be an electronic device that may be comprised of, for example, data storage, communication, or computer code execution capabilities and may contain information on patients registered for a healthcare encounter in an office.

The office interface **210** can be comprised of software that may be used by people to interact with the encounter module **200**. Other software may also be included in the office interface **210**. In one embodiment, the office interface **210** also can be comprised of an electronic device, such as a computer, tablet device, or smartphone. In various embodiments, office staff can use the office interface **210** to, for example, create records or enter patient data into the encounter module **200** for patients who register in the clinic. This data entry can be enabled in many ways, including for example, manual entry, entry by copying previously-entered data from an office database **220**, or entry using a unique identifier that can be compared to an office database **220** or external database **230**, such as an Internet or cloud-based database, to retrieve pre-entered data for a patient matching that unique identifier. In one embodiment, registration can be completed with a code, such as an encounter code, in a fashion similar to checking in for an airline flight at an airport. This code could, for example, be linked to patient or provider information required for registration purposes.

The office database **220** can be configured to store data from past encounters, as well as other types of data. The external database **230** can be also configured to store at least data from past encounters, as well as other types of data. The encounter module **200** can be configured, for example, to access, copy, modify, delete, and add information, such as patient data, to and from the office database **220** and external database **230**. The external database **230** can be configured to, for example, receive, store, retrieve, and modify encounter information from other offices.

In one embodiment, patients may self-register or check into the clinic by using the office interface **210** to, for example, create an encounter record, enter encounter information manually, select their information from a pre-populated office database **220**, or enter a unique identifier that can be compared to an office **220** or external database **230** to retrieve their other associated data.

The encounter module **200** can be configured to contain patient records, which may also contain clinic processes **205**. A clinic process **205** can be comprised of, for example, orders from the healthcare provider for the patient's care. In one embodiment, the orders may indicate the sequence of evaluations and care. For example, a provider may indicate that a given patient should undergo a medical history followed by an examination with various medical devices followed by an assessment by the provider.

In one embodiment, the clinic process **205** can be configured to enable alteration of the orders, the order sequence or both the orders and their sequence by, for example, office staff or the provider. Examples of this could include insertion of an educational session about a given disease prior to a discussion with the provider, deletion of a treatment denied by a patient, or switching the sequence of two test procedures.

In some embodiments, the prescribed orders themselves may contain lists of prescribed tests to be performed on a given device. For example, as part of a technician work-up order, a provider may prescribe blood pressure and pulse measurement testing to be performed on a patient using a device in the clinic. The order and prescription of these tests may change throughout the encounter having been altered by office staff, the provider, or electronic devices.

In one embodiment, a diagnosis or medical history of a patient from the encounter module **200** can be included in the clinic process **205** and may be used, for example, to determine or alter the clinic process **205**. For example, a history of past visits and evaluations may alter the tests that are ordered or the devices that are used during an encounter.

In one embodiment of an electronic encounter portal, a tracking system **240** can be configured to enable a component of an electronic encounter system to determine the physical location or position of, for example, patients, providers and staff in the office space. In one embodiment, a component of the electronic encounter system can use data from the tracking system **240** to monitor the progress of patients through a clinic process **205**. In one embodiment, this tracking system **240** can be comprised of a sensing technology, such as a compass, radiofrequency antenna, acoustic sensor, imaging sensor, or GPS sensor that determines the position of the sensor in relation to known objects such as office walls, positioning beacons, WiFi transmitters, GPS satellites, magnetic fields, or personnel outfitted with radiofrequency ID tags.

The tracking system **240** may also be configured to perform mathematical calculations, such as triangulation, to analyze signals from the sensors. The tracking system may also compare signals from the sensors to databases of known signals collected at a prior date, such as comparing a measured magnetic field to a database of known magnetic fields at every position in the clinic. In some embodiments, this tracking system **240** can also be comprised of an emission technology such as a radiofrequency beacon, to indicate the position of an object in the office space.

The tracking system **240** may also be configured to localize the position of a person or object using a known map of the office space as shown in FIG. **3**. Knowledge of the position of sensors, patients, or personnel in an office space map may enable the tracking system **240** to provide information to the encounter module **200** regarding the location of patients, providers or other office personnel in an office space.

The tracking system **240** can also be configured to provide position information to other components of the electronic encounter system, such as the office interface **210** or the patient interface **250**, either directly or via an intermediate component such as the encounter module **200**. An example of how this information might be used is to provide status information to a user as to the progress or status of other people in the office.

In one embodiment, office personnel can use the office interface **210** to monitor the location or progress of, for example, providers, staff or patients within the office space. This monitoring may include calculation of, for example, time spent in a given location, progress through a clinic process **205**, or current status of activity, such as waiting, working or occupied. This monitoring ability can be advantageous so that office staff can, for example, monitor delays in the provision of patient care or identify recurrent patient flow bottlenecks that can be reduced through optimization of clinic flow.

The patient interface **250** can be comprised of software that may be used by patients to interact with the encounter module **200**. In one embodiment, the patient interface **210** can also comprise an electronic device, such as a computer, tablet device, or smartphone, which can be supplied by the clinic or be supplied by the patient. For the purpose of clarity, in one embodiment, the patient interface **250** may be the patient's own electronic device, such as a smartphone or computer that can be configured with patient interface **250** software. In other embodiments, the office interface **210** and the patient interface **250** may be the same device, such as with a mobile tablet computer or smartphone, that can be configured to allow a patient to perform actions of both an office interface **210**, such as registration, and actions of a patient interface **250**, such as viewing patient data or asking electronic questions of office personnel.

The encounter module **200** and the patient interface **250** can be configured to interface with various devices **260** in the clinic. These devices **260** can include but are not limited to diagnostic instruments, such as blood pressure monitors, imaging devices or other measurement instruments, or therapeutic devices, such as lasers or injection apparatuses. The encounter module and the patient interface **250** can be configured to send and receive data with these devices **260**. Communication with these devices **260** can be enabled by but is not limited to wired connections, wireless connections and printed methods, such as bar codes or QR codes.

With reference to FIG. **3**, there is illustrated a map of a healthcare office. In one embodiment, the patient can register for a healthcare encounter at the office entrance **300**. In other embodiments, the patient may register for a healthcare encounter at a place other than entrance **300**. In one embodiment, encounter registration can be completed by a human receptionist who may enter information into the encounter module **200** through the office interface **210**. In another embodiment, registration may be completed by the patient for example by using an assisted or self-service kiosk configured with an office interface **210**.

A kiosk may, for example, be comprised of a location where an untrained user can perform a task or tasks, such as checking in for an appointment or performing a requested test. This kiosk may be comprised of electronics or computer equipment, may be shielded from the view of other people in the same room, may be comprised of seating, and may provide a material result to a user. Other kiosk configurations are possible.

In another embodiment, the patient may register for the encounter with an office interface **210**, such as a tablet computer, that is supplied by the clinic and may have been configured with software to interface with the encounter module **200**. In still another embodiment, the user may register for the encounter with their own portable device, such as a mobile phone or tablet computer, that can be configured with software that can allow it to act as either or both an office interface **210** or as a patient interface **250**.

In various embodiments, orders or steps in an electronic encounter system can include, for example, asking a patient to sit in waiting area **310**, asking a patient to proceed to testing area **320** or asking a patient to go to clinic area **330**. These orders can be conveyed to the patient by, for example, the patient interface **250** or by office personnel. In one embodiment, the desired disposition for a patient can be determined by a clinic process **205** that may have been entered into the encounter module **200** and communicated to the patient via the patient interface **250** or office personnel.

In one embodiment, the patient interface **250** can be configured to use information from the tracking system **240** for example, to determine the location of the patient in the clinic, to determine the next planned location for a patient from a clinic process **205** in the encounter module **200**, or to communicate directions to a patient using the patient interface **250**.

Referring to FIG. **10**, in one embodiment **340**, a line can be drawn on a schematic map of the clinic space on patient interface **250** to show the patient how to walk to their next destination in the clinic. In another embodiment, the patient interface **250** can be configured to communicate directions verbally, such as by text-to-speech software.

In one embodiment, the encounter module **200** may be configured to monitor which rooms and devices in an office are "in use" based on information provided by the tracking system **240**. In one embodiment, the encounter module **200** may be configured to select a next location for a patient based on which rooms or devices **260** may be free to use. For example, if the encounter module **200** determines that a device **260** required for the next stage of a clinic process **205** is occupied or busy, the encounter module **200** can be configured to alter the clinic process **205** by inserting, for example, a waiting room order that, for example, can be removed from the clinic process **205** when the required device is free for use.

In one embodiment, the encounter module **200** can be configured to monitor utilization of a device **260** or clinic area that may be required for the next stage of a clinic process **205** and may be configured to insert an order for a patient to move to that device **260** or clinic area when it becomes free for use.

In another embodiment, the encounter module **200** can be configured to monitor the list of patients waiting for a provider and also to determine which providers have the shortest waiting lists or waiting times based on, for example, the number of patients in a waiting patient list and the average time the provider spends with each patient. The encounter module **200** can be configured to use this information, for example, to assign patients to providers with the shortest wait times so as to improve clinic flow. Numerous other embodiments of device decisions based on dynamic knowledge of device and space utilization within an office space are possible.

An example of a healthcare encounter is shown in FIG. **11**. In one embodiment, the first step in the encounter may be registration **400**, which can be completed, for example, by office staff or by the patient using, for example, an office interface **210**. Encounter registration **400** may be comprised of many steps such as signing the patient's name and address, presenting identification, verifying insurance status, paying co-payments due prior to the encounter, consenting to be seen by the provider, consent to privacy regulations or payment of other fees. In other embodiments, the user may skip registration **400** and may proceed to other steps, such as examination **410**.

In one embodiment, one step in an automated healthcare encounter can be verification of the user's identity. This may be accomplished, for example, as part of registration **400**, as part of examination **410**, prior to using any device **260**, or at other times in the encounter. A mobile patient interface **250** may be advantageous since it can verify the user's identity once and then communicate this identity to, for example, the encounter module **200**, to providers, or to subsequent devices used throughout the encounter, such as devices **260**.

In various embodiments, the patient interface **250** can be configured to verify the user's identity through biometrics, such as through recognition of the patient's face, voice, fingerprint or other unique physical aspects of the subject. In other embodiments, the patient interface **250** can be configured to verify the user's identity through confirmation of a user's unique data, such as their names, date of birth, addresses, mother's maiden name, or answers to questions only known to the user. In another embodiment, the patient interface **250** can be configured to verify the user's identity through confirmation of code, such as a password or secret code known only to the user. In still another embodiment, the patient interface **250** can be configured to verify the user's identity through coupling of a device carried only by the user, such as a key, electronic device, bar code, or QR code.

In one embodiment of an electronic healthcare encounter, the user may complete the history portion of their examination as part of their overall encounter. As discussed previously, in various embodiments, the history portion of the encounter can be collected, for example, by office staff or by the patient themselves. Office staff may use the patient interface **250** or the office interface **210** to conduct or enter results from a patient history. In other embodiments, the patient may use the patient interface **250** to complete their own history without interacting with office staff.

In various embodiments, the questions can be configured in a form that facilitates responses using written, mouse-based, tablet-based or voice entry such as multiple choice, true or false, or pull-down menu selections. In other embodiments, the questions may require free entry such as by writing, voice dictation, or keyboard entry. In these examples, the patient interface **250**, the office interface **210**, or the encounter module **200** may be configured to interpret electronic forms of these inputs, such as electronic writing or voice dictation.

In one embodiment, the history portion of the encounter may be comprised of a standard series of questions. In another embodiment, the series of questions may be based on, for example, a preference specified by the provider, the patient's diagnosis, the patient's symptoms or some other unique aspect of the encounter.

In still another embodiment, the history portion of the encounter can be comprised of questions from a database whereby the next question to be asked can be determined, for example, based on an answer to a previous question. This dynamically-traversed database of questions may use answers from a question to determine subsequent questions to ask or to determine sets of questions to ask based on a tree organization of questions in the database. For example, if a patient reports color vision loss, the system can be configured to add a series of questions related to color vision loss to its list of questions even if they were not previously included in the set of questions to be asked. In later questioning, if the patient reports pain on eye movement, the system can be configured to add, for example, questions related only to pain on eye movement or questions related to pain on eye movement and color vision loss. The dynamic allocation of new questions based on answers to previous questions can be configured such that a provider can allow or disallow such a feature.

In one embodiment, a dynamically-traversed electronic questionnaire can be configured to assign priority values to each question so that certain questions can be asked before other questions. In still another embodiment, the system can provide a running count of the total number of questions to be asked to the patient along with an estimated total time to completion. In related embodiments, the system can be configured to allow users or providers to shorten the questionnaire, such as by excluding lower priority questions, based on aspects of the dynamic questionnaire such as it taking too much time or involving too many questions and answers.

In another embodiment, the patient interface **250** can be configured to allow the user to change display parameters, such as size, color and font type, used to display questions with the patient interface **250**. In other embodiments, the patient interface **250** can be configured to read questions aloud, for example using a text-to-speech system or pre-recorded voices, or to ensure privacy by providing a headphone jack where the user can connect headphones.

In one embodiment, the encounter module **200** can be configured to direct devices **260** to perform tests and store results associated with the clinic process **205** and the patient's information contained within the encounter module **200**. The encounter module **200** can be configured to communicate with these devices **260** using a direct wired connection, such as a USB, Ethernet or serial connection, a wireless connection, such as Bluetooth® or 802.11, an intermediate electronic device, such as a USB key, memory card or patient interface **250**, or a physical coded embodiment such as a bar code or QR code.

In one embodiment, the encounter module **200** or patient interface **250** can be configured to alter the list of tests requested for an encounter based on answers to history questions or results from testing on devices **260**. The encounter module **200** or the patient interface **250** can also be configured to direct a device **260** to conduct a new test or tests in addition to or in place of the old test or tests. Alteration of the clinic process **205** by the encounter module **200** or patient interface **250** can be allowed or disallowed by a provider either globally or specifically, such as based on answers to specific questions or categories of questions, using, for example, the office interface **210**.

In one embodiment, the encounter module **200** or the patient interface **250** can be configured to initiate operation of a device **260**, such as an instrument to measure vision. In another embodiment, the encounter module **200** or the patient interface **250** can be configured to allow the user to initiate operation of a device **260**, such as by saying "ready," pushing a button or pressing a pedal that may be attached to the patient interface **250**. In still another embodiment, the encounter module **200** or the patient interface can be configured to allow the user to initiate operation of the device **260**, such as by saying "ready," pushing a button or pressing a pedal, through the device **260**.

As discussed previously, the encounter module **200** or the patient interface **250** can be configured to receive data, such as examination results, from devices, such as the tracking system **240**, the patient interface **250**, or devices **260**. As discussed above, the encounter module **200** can be configured to communicate with these other components using, for example, a wired connection, a wireless connection, an intermediate electronic, or using a physical embodiment.

Collection of data from numerous devices by the patient interface **250** or encounter module **200** can be particularly advantageous by reducing transcription or sorting errors that can occur when human laborers are involved in these processes or by centralizing all encounter data in one location.

Various components in the electronic encounter system, such as the encounter module **200**, can be configured to compile encounter data into a digital package or packages that can be uploaded to, for example, an electronic health record system either in the office, such as the office database **220**, or outside the office via secure external communication **235**, transmitted to other individuals on a patient's healthcare team via secure external communication **235**, reviewed directly by the provider on a patient interface **250** or office interface **210**, or stored on an accessible external database **230**. The external database **230** can be configured to be accessible remotely, such as via the Internet, for example, to facilitate sharing of exam data between providers or to facilitate access by the patient to their own healthcare data.

As discussed previously, the encounter module **200** can be configured to track both patients and clinic personnel using the tracking system **240**. The encounter module **200** can be configured to store tracking information such that it, for example, can be viewed or analyzed using an office interface **210**. By tracking a patient's location over time, the encounter module **200** can be configured to develop clinic patient flow maps that may enable staff to identify both acute and chronic problems with clinic flow. For instance, identification of a patient by the encounter module **200** who has been waiting longer than a pre-defined threshold value stored in a clinic process **205** can alert the staff, for example via an office interface **210**, to address problems with that patient's encounter that might be leading to this delay. Identification of chronic bottlenecks and waiting points across numerous encounters can allow practices to optimize their workflow.

Providers can be tracked in several ways. In one embodiment, mobile office interfaces **210** can be configured with tracking systems **240** to identify the location and identity of providers carrying them. In another embodiment, the patient interface **250** can be configured to require providers to log in whenever they are consulting with a patient. In still another embodiment, the tracking system **240** can be configured to monitor the location or identity of providers wearing identifiers, such as RFID tags. In other embodiments, the encounter module **200** could be configured to communicate updates to patients, such as by using the patient interface **250**, to, for example, estimate the approximate wait times until the provider sees them or to convey how many patients still need to be seen by the provider before they are seen by the provider.

The electronic encounter portal can also be configured to provide entertainment or education to a patient. For example, the patient interface **250** can be configured to provide Internet access **235**, access to previous encounter records stored on the encounter module **200**, or access to previous encounter records stored on the external database **230**. The patient interface **250** can also be configured to provide access by the patient to educational resources, potentially targeted toward the diagnosis or future treatments for a patient that may be stored on components such as the encounter module **200**. In one embodiment, the provider can use a patient interface **250** or an office interface **210** to enter orders for an educational program into a clinic process **205**.

In another embodiment, the patient interface **250** can be used to inform a patient about clinic resources, such as clinical trials, support programs, therapeutic services, restrooms, refreshments, etc. based on information stored on the encounter module **200**. The encounter module **200** can also be configured to direct patients to these resources, such as restrooms, based on information from the tracking system **240** and requests from the patients using the patient interface **250**. The encounter module **200** can also be configured to manage communications between patients, using a patient interface **250** and office staff, such as by using an office interface **210**.

In one embodiment, the patient interface **250** can be configured to store data from devices and, in an embodiment that is mobile such as a tablet or smartphone, can allow the patient to transport encounter data through the clinic process **205** for review by or with the provider. In another embodiment, the office interface **210** can be configured to enable data to be uploaded for review by the provider. Both the patient interface **250** and the office interface **210** can be configured to access and use prior visit data from the encounter module **200** to enhance assessments of a patient's healthcare status. Similarly, both the patient interface **250** and the office interface **210** can be configured to access prior data from the external database **230** to enhance assessments of a patient's healthcare status.

In related embodiments, the encounter module **200** and the external database **230** can be configured to act as common locations for encounter data that can be accessed by both patients and providers. The external database **230** can be configured to allow remote access to encounter data by both providers and patients when they are outside of the office. Similarly, the external database **230** can be configured to receive data from devices **260** at locations outside of the described office and share these results with the encounter module **200** for example, to enable automated remote healthcare encounters.

In one embodiment of an electronic encounter portal, a check-out procedure **420** may be the last order or step in a clinic process **205**. In various embodiments, the office interface **210** or the patient interface **250** can be configured to allow providers to enter orders for future encounters such as testing or therapies. In other embodiments, the office interface **210** can be configured to enable the provider to enter billing information to be submitted for insurance reimbursement or directly charged to the patient. In still another embodiment, the office interface **210** can be configured to allow the provider to recommend a follow-up interval for the next encounter. In a related embodiment, the office interface **210** or the patient interface **250** can be configured to allow the patient to select the best time and data for a follow-up encounter. In another embodiment, the office interface **210** can be configured to allow the provider to order educational materials or educational sessions for the patient that may occur after the encounter concludes.

Accordingly, various embodiments described herein can reduce the need for clinic personnel to perform these tasks. In addition, various embodiments enable users to conduct their own complete eye exams.

Automated Eye Examination

FIG. **12** shows an example of a binocular eye examination system based on optical coherence tomography. Component **500** may be comprised of the main electronics, processors, and logic circuits responsible for control, calculations, and decisions for this optical coherence tomography system. Light can be output from light source **502**, which may be controlled at least in part by component **500**. The light source may be comprised of a broadband light source such as a superluminescent diode or tunable laser system. The

center wavelength for light source **502** can be suitable for optical coherence tomography of the eye, such as 840 nm, 1060 nm, or 1310 nm. The light source **502** may be electronically controlled so that it can be turned on, off or variably attenuated at various frequencies, such as 1 Hz, 100 Hz, 1 kHz, 10 kHz or 100 kHz. In one embodiment, light from light source **502** can travel through interferometer **504**, which may be comprised of a Mach Zehnder or other type of interferometer, where a k-clock signal can be generated. This electronic signal can be transmitted to electronics on component **500** or other components in the system and can be captured on a data acquisition system or used as a trigger for data capture.

The k-clock signal can be used as a trigger signal for capturing data from balanced detectors **518***r* and **518***l*. Alternatively, the k-clock signal can be captured as a data channel and processed into a signal suitable for OCT data capture. This k-clock signal can be captured all of the time, nearly all of the time or at discrete times after which it would be stored and recalled for use in OCT capture. In some embodiments, various parameters of the k-clock signal, such as frequency or voltage, can be modified electronically, such as doubled or quadrupled, to enable deeper imaging in eye tissues. In various embodiments with light sources that sweep in a substantially linear fashion, the k-clock can be removed and a regular trigger signal may be employed. In various embodiments, the trigger signals used by electronics **595***r* and **595***l* may be synchronized with other components of the system, such as mirrors, variable focus lenses, air pumps and valves, pressure sensors and flow sensors.

Most of the light, such as 90% or 95%, that enters the interferometer **504** can be transmitted through interferometer **504** to a beam splitter or coupler **510**. As used herein, "coupler" may include splitters as well as couplers. Beam coupler **510** can split the light from interferometer **504** or light source **502** to two output optical paths, specifically right and left, that lead directly to couplers **515***r* and **515***l*. Henceforth, designation of a device or component with a suffix of 'r' or 'l' will refer to two devices that may be of the same type but are located in different optical paths. For example, one component may be located in the optical path of the right eye, designated as 'r,' and the other is located in the optical path of the left eye, designated as 'l.'

The optical paths in this system may be comprised of fiber optics, free space optics, a mixture of free space and fiber optics. Other combinations are also possible. The split ratio of coupler **510** can be a predefined ratio, such as 50/50 or 70/30. Light from coupler **510** can travel to couplers **515***r* and **515***l*. Couplers **515***r* and **515***l* may also split light from coupler **510** with a predefined split ratio such as a 50/50, 70/30, or 90/10. The split ratios for couplers **510**, **515***r*, and **515***l* may be the same or different split ratios.

One portion of light from couplers **515***r* and **515***l*, such as 70%, can travel to a so-called 'reference arm' for each of the right and left optical paths. The reference arm of a light path is distinguished from the so-called sample arm of the light path since light in the reference arm of the system does not interface with eye tissue directly whereas light in the sample arm is intended to contact eye tissue directly.

The main component in the reference arm may be an optical delay device, labeled as **516***r* and **516***l* in the right and left optical paths of the system. Optical delay devices can introduce a delay, such as 1 picosecond, 10 picoseconds, or 100 picoseconds, into a light path to enable matching of the overall path length of one optical path to the optical path length of another light path. In various embodiments, this optical delay may be adjustable, such as with an adjustable free light path between two collimating optical devices, a fiber stretcher that increases or decreases the length of a fiber optic, or a fiber Bragg grating that delays light based on changes in the angle of incidence of light.

In other embodiments, this optical delay line can include variable attenuators to decrease or increase the transmission of light, optical switches or mechanical shutters to turn the light off or on. Although pictured in the reference arm of this system, an optical delay line can also be entirely included in the sample arm optical path for each eye or contained in both the reference and sample arm light paths. Other combinations of sample and reference light paths are also possible.

In one embodiment, light from optical delay devices **516***r* and **516***l* can travel to couplers **517***r* and **517***l* where it may be combined with light from the sample arm that has been transmitted from couplers **515***r* and **515***l*. Couplers **517***r* and **517***l* may combine light from two light paths with a predefined ratio between paths such as a 50/50, 70/30, or 90/10. Light from couplers **517***r* and **517***l* may travel through two outputs from couplers **517***r* and **517***l* to balanced detectors **518***r* and **518***l* where the light signal can be transformed into an electrical signal, for example through the use of photodiodes configured to detect the light input from couplers **517***r* and **517***l*.

The electrical signal generated by balanced detectors **518***r* and **518***l* can be in various ranges, including but not limited to −400 mV to +400 mV, −1V to +1V, −4V to +4V and have various bandwidths, including but not limited to 70 MHz, 250 MHz, 1.5 GHz. The electrical signal from balanced detectors **518***r* and **518***l* may travel via an electrical connection, such as a coaxial cable, to electronics **595***r* and **595***l* where it can be captured by a data acquisition system configured to capture data from balanced detector devices. Although not pictured here, a polarization sensitive optical component can be disposed before balanced detectors **518***r* and **518***l* to split two polarities of light in a single light path into two optical paths. In this embodiment, two optical paths leading to balanced detectors **517***r* and **517***l* would be split into a total of four optical paths, which would lead to two balanced detectors on each side.

One portion of light from couplers **515***r* and **515***l*, such as 30% or 50%, can travel to a so-called sample arm of each of the right and left optical paths. In various embodiments, the system may be configured to transmit the light through fiber optic cable or through free space optics. Light from couplers **515***r* and **515***l* can travel to optics **520***r* and **520***l*, which may be collimators configured to collimate the light from couplers **515***r* and **515***l*. Light from optics **520***r* and **520***l* can travel to lens systems **525***r* and **525***l*, which may be comprised of fixed focus or variable focus lenses.

In various embodiments, these lenses can be fabricated from plastic or glass. In other embodiments, these lenses may be electrowetting lenses or shape-changing lenses, such as fluid-filled lenses, that can vary their focal distance based on internal or external control mechanisms. In one embodiment, variable focus lenses in lens systems **525***r* or **525***l* may have their focal length modified by electrical current or voltage applied to lens systems **525***r* or **525***l*. This control may come from electrical components **595***r* and **595***l* and the parameters of this control may be based on pre-determined values or may be derived during operation of the system based on input received from other components of the system.

The lenses in lens systems **525***r* and **525***l* can be configured to have anti-reflective coatings, embedded temperature sensors, or other associated circuitry. Lens systems **525***r* and **525***l* may be comprised of a single lens or multiple lenses.

The lenses comprising systems **525***r* and **525***l* may be present at all times or may be mechanically moved in and out of the light path such as by an attached motor and drive circuit under electrical control from components **595***r* and **595***l*. Configuration of lens systems **525***r* and **525***l* to be moveable can enable imaging at different depths in an eye tissue by introducing and removing vergence in the optical system.

Light from lens systems **525***r* and **525***l* can travel to movable mirrors **530***r* and **530***l*. Movable mirrors **530***r* and **530***l* may be comprised of MEMS (microelectromechanical systems) mirrors, controlled by galvanometers, or moved by other means. Movable mirrors **530***r* and **530***l* can be comprised of a single mirror that reflects light across 2 axes, such as X and Y, can be comprised of a single mirror that reflects light across one axis only, or can be comprised of two mirrors that each reflect light across one axis only said axes being substantially perpendicular to each other.

Electrical control of mirrors **530***r* and **530***l*, which may control each axis of reflection independently, can be provided by components **595***r* and **595***l*. The electronic control of mirrors **530***r* and **530***l* may be configured to enable variable amplitude deflections of mirrors **530***r* and **530***l*. For example, for a given drive frequency in a given axis, the current or voltage applied to mirrors **530***r* and **530***l* may enable larger or smaller amplitude deflections of the mirror surface, thus creating a zoom effect where the created image can be made smaller or larger.

Light that has been reflected from movable mirrors **530***r* and **530***l* can travel to lens systems **535***r* and **535***l*. Lens systems **535***r* and **535***l* may be fixed or variable focus lenses that are located in the optical light path at all times or only part of the time. Electrical control of lenses **535***r* and **535***l*, can be conducted by components **595***r* and **595***l* and may include for example moving these lenses in and out of the light path or changing their focal lengths. Other actions are also possible.

Light from lens systems **535***r* and **535***l* can travel to optics **540***r* and **540***l*, which may be comprised of dichroic mirrors or couplers. Optics **540***r* and **540***l* may be configured to transmit light from lens systems **535***r* and **535***l* and combine it with light from lens systems **545***r* and **545***l*. Light from optics **540***r* and **540***l* can travel to eye pieces **542***r* and **542***l* before being transmitted to the right and left eye tissues.

Eye pieces (or oculars) **542***r* and **542***l* can be configured as multi-element lens systems such as Ploessl-type eyepieces, Erfle-type eyepieces, telescopes or other designs. In some embodiments, optics **540***r* and **540***l* may be configured to be part of or inside of eyepieces **542***r* and **542***l*. In other embodiments, variable focus lenses or polarization-sensitive optics and beam splitters can be configured inside eyepieces **542***r* and **542***l* to enable wider axial focusing ranges in eye tissues or simultaneous focusing of light from two axial locations in eye tissues. Eyepieces **542***r* and **542***l* may be configured with optical components without any refractive power, such as optical windows, that may be physically attached or separate from the other lenses in the system.

Light entering the right and left eyes can be reflected back through each optical path to enable optical coherence tomography. In one embodiment, the path of back reflected light originating from light source **502** can travel from each eye to eyepiece **542** to optics **540** to lens system **535** to movable mirror **530** to lens system **525** to optics **520** to coupler **515** to coupler **517** to balanced detector **518**. Various calculations and logic-based processes can be completed by components **595***r* and **595***l* based on data contained in signals received from balanced detectors **518***r* and **518***l*.

As discussed previously, timing of capture of the signals received by components **595***r* and **595***l* may be controlled by other inputs, such as the k-clock input, dummy clock input, or other electrical signal. Electronics **500**, **595***r*, and **595***l* may be configured to have digital signal processors (DSPs), field-programmable gate arrays (FPGAs), ASICs, or other electronics to enable faster, more efficient or substantially real-time processing of signals received by components **595***r* and **595***l*. Electronics **500**, **595***r*, and **595***l* may be configured with software, such as a real-time operating system, to enable rapid decisions to be made by said components.

In various embodiments not illustrated here, the eye tissues may be replaced by calibration targets that, for example, occlude the eyepieces, dispose a mirror target at various distances in front of the eyepieces, or provide an open air space for calibration. Electronics **500** may be configured to control the introduction of these non-tissue targets, such as when the eyes are not present in the optical system. In other embodiments, electronics **500** may be configured to dispose powered or moveable components of the system to various states, such as "off," "home," or "safety" at various times, such as the beginning, middle and end of a test.

Components **595***r* and **595***l* can also be configured to control light sources **585***r*-**588***r* and **585***l*-**588***l*, which may be comprised of various light sources such as, for example, laser diodes, light emitting diodes, or superluminescent diodes. In the illustrated embodiment, only four light sources **585***r*-**588***r* and **585***l*-**588***l* are shown. In various embodiments, different numbers of light sources **585***r*-**588***r* and **585***l*-**588***l* may be used and different wavelengths of light sources may be used. In one embodiment, one each of a blue-colored, green-colored, red-colored and near infrared diode can be included in the light source groups **585***r*-**588***r* and **585***l*-**588***l*.

In other embodiments, light sources **585***r*-**588***r* and **585***l*-**588***l* may be comprised of tunable light sources capable of producing numerous spectra of light for the purposes of hyperspectral imaging. For example, employing various light sources in the visible spectrum capable of producing narrow bands of light centered at characteristic peaks of absorption or reflectivity for oxyhemoglobin and deoxyhemoglobin can be used to enable hyperspectral imaging. Similarly, numerous individual light sources can be used to achieve the same effect as a light source with a tunable wavelength.

These light sources can be configured to be controlled by components **595***r* and **595***l* using, for example, pulse-width modulation, current modulation, voltage modulation, or other electrical control means. In one embodiment, the modulation frequency of at least one light source can be modified to correct for chromatic aberration from the optics between the light sources and the eye. For example, the modulation frequency of the red channel could be variably increased or decreased in different mirror positions to account for lateral chromatic spread between the red light source and other colors such as blue or green.

Light from light sources **585***r*-**588***r* and **585***l*-**588***l* can travel to optics **580***r*-**583***r* and **580***l*-**583***l* that may, for example, be focusing optics. Light from optics **580***r*-**583***r* and **580***l*-**583***l* can then travel to optics **575***r*-**578***r* and **575***l*-**578***l* that may, for example, be focusing optics. Each path of light can contain a single frequency of light, such as 450 nm, 515 nm, 532 nm, 630 nm, 840 nm, or 930 nm or multiple frequencies of light.

Each path of light from light sources **585***r*-**588***r* and **585***l*-**588***l* may be reflected off optics **571***r*-**574***r* and **571***l*-

574*l* which may, for example, be dichroic mirrors or couplers and may be specifically configured to reflect and transmit light based on their position in the optical path. For example, one optic may be configured to transmit light with a wavelength less than 500 nm and reflect light with a wavelength greater than 500 nm.

Optics **571***r*-**574***r* and **571***l*-**574***l* can be configured to join together light from different light sources **585***r*-**588***r* and **585***l*-**588***l* into a single, substantially coaxial beam of light that can travel to optics **561***r* and **561***l*. Optics **561***r* and **561***l* may be dichroic mirrors or couplers and may be configured to have a pre-defined split ratio of light entering from different directions or having different wavelengths, such as 90/10, 50/50, and 10/90.

A portion of light from optics **571***r*-**574***r* and **571***l*-**574***l* can be transmitted through optics **561***r* and **561***l* to sensors **566***r* and **5661** which may, for example, be photodiodes or other components capable of sensing light. Signals from sensors **566***r* and **5661** can be configured to be transmitted along electrical connections between sensor **566***r* and electrical component **595***r* on the right side and sensor **5661** and electrical component **595***l* on the left side. In one embodiment, sensors **566***r* and **5661** can be configured to monitor the total light power being emitted by light sources **585***r*-**588***r* and **585***l*-**588***l*.

The portion of light reflected off optics **561***r* and **561***l* from optics **571***r*-**574***l* and **571***l*-**574***l* can travel to lens systems **560***r* and **560***l*. Lens systems **560***r* and **560***l* may be comprised of fixed focus or variable focus lenses. In various embodiments, these lenses can be fabricated from plastic or glass. In other embodiments, these lenses may be electrowetting lenses or shape-changing lenses, such as fluid-filled lenses, that may vary their focal distance based on internal or external control mechanisms.

In one embodiment, variable focus lenses in lens systems **560***r* and **560***l* may have their focal length modified by electrical current or voltage applied to the lens systems. This control may be under the direction of electrical components **595***r* and **595***l* and it may be based on pre-determined values or be derived during operation of the system based on input received from other components of the system.

The lenses in lens systems **560***r* and **560***l* can be configured to have anti-reflective coatings, embedded temperature sensors, or other associated circuitry. Lens systems **560***r* and **560***l* may be comprised of a single lens or multiple lenses. The lenses comprising systems **560***r* and **560***l* may be present in the light path at all times or may be mechanically moved in and out of the light path by an attached motor and drive circuit under electrical control from components **595***r* and **595***l*. Configuration of lens systems **560***r* and **560** to be moveable can enable imaging at different depths in an eye tissue by introducing and removing vergence in the optical system.

Light from lens systems **560***r* and **560***l* can travel to lens systems **555***r* and **555***l*. In some embodiments, lens systems **555***r* and **555***l* can be located in their respective optical paths at all times. In other embodiments, lens systems **555***r* and **551** may be moved in and out of the optical paths based on electrical signals from components **595***r* and **595***l*.

Light from lens systems **555***r* and **555***l* can travel to movable mirrors **550***r* and **550***l*. Movable mirrors **550***r* and **550***l* may be comprised of MEMS mirrors, controlled by galvanometers, or moved by other means. Movable mirrors **550***r* and **550***l* can be comprised of a single mirror that reflects light across 2 axes, such as X and Y, can be comprised of a single mirror that reflects light across one axis only, or can be comprised of two mirrors that each reflect light across one axis only said axes being substantially perpendicular to each other.

Electrical control of mirrors **550***r* and **550***l*, which can control each axis of reflection independently, can be provided by components **595***r* and **595***l*. Mirrors **550***r* and **550***l* may have one axis of fast resonant movement, one axis of slow resonant movement, two slow axes of movement, one fast resonant axis and one slow axis of movement, or two fast resonant axes of movement.

The electronic control of mirrors **530***r* and **530***l* may be configured to enable variable amplitude deflections of mirrors **530***r* and **530***l*. For example, for a given drive frequency in a given axis, the current or voltage applied to mirrors **530***r* and **530***l* may enable larger or smaller amplitude deflections of the mirror surface, thus creating a zoom effect where the created image can be made smaller or larger.

Light from movable mirrors **550***r* and **550***l* can travel to lens systems **545***r* and **545***l*. Lens systems **545***r* and **545***l* may be configured to introduce variable amounts of optical cylinder power into the optical light paths. In one embodiment, the magnitude and axis of the cylindrical optical power introduced into the optical paths by lens systems **545***r* and **545***l* can be configured to correct an astigmatism present in an eye interfacing with this system.

Lens systems **545***r* and **545***l* can comprised of two cylindrical lenses configured to counter-rotate and co-rotate with each other, an electrically controlled variable focus, liquid filled lens, or other method of introducing cylindrical optical power into a light path. Although not illustrated here, lens systems **545***r* and **545***l* can also be located between mirrors **530***r* and **530***l* and optics **540***r* and **540***l* in the OCT light path.

Light from lens systems **545***r* and **545***l* can travel to optics **540***r* and **540***l* where it may be reflected to combine with light originating at light source **502**. In one embodiment, an exit pupil expander can be disposed between moveable mirrors **550***r* and **550***l* and the eye tissues to increase the size of the exit pupil created at the eye tissue by mirrors **550***r* and **550***l*.

Light from lens systems **545***r* and **545***l* may be transmitted through eyepieces **542***r* and **542***l* after which it may enter the right and left eyes of a subject. Light transmitted through eyepieces **542***r* and **542***l* can be configured to be seen by the subject as organized light, such as in a retinal scanning display system, can be configured to be seen by the subject as video-rate imaging through modulation of light sources **585***r*-**588***r* and **585***l*-**588***l* by components **595***r* and **595***l*, or can be configured to broadly stimulate the eye with light such as for measurements of pupillary reactions to light stimuli.

Light from lens systems **545***r* and **545***l* can also be configured to reflect back out of the eye and through eyepieces **542***r* and **542***l*, off optics **540***r* and **540***l*, through lenses systems **545***r* and **545***l*, off moveable mirrors **550***r* and **550***l*, through lens systems **555***r*, **555***l*, **560***r*, and **560***l* and then through optics **561***r* and **561***l*. Light transmitted through optics **561***r* and **561***l* can be detected by sensors **567***r*-**570***r* and **567***l*-**570***l* that may, for example, be comprised of photodiodes.

In various embodiments, this light is split into predefined wavelength bands, such as 440 nm-460 nm, 510 nm-580 nm, 625 nm-635 nm, or 930 nm, by dichroic mirrors **562***r*-**565***r* and **562***l*-**565***l*. In other embodiments, separation of light from optics **561***r* and **561***l* into bands can be achieved by the use of filters that selectively transmit or reflect wavelength bands of interest.

In still other embodiments, separation of light from optics **561***r* and **561***l* into bands can be achieved by configuring the system with sensors **567***r*-**570***r* and **567***l*-**570***l* that only produce electrical signals in specifically targeted bands, such as 400-500 nm, 600-800 nm or >900 nm. Electrical signals from sensors **567***r*-**570***r* and **567***l*-**570***l* can travel to components **595***r* and **595***l* across electrical connections to enable imaging of tissues in the eye by sensing the light originating at light sources **585***r*-**588***r* and **585***l*-**588***l* back reflected in desired wavelength bands.

FIG. **13** shows an example of a display of eye examination data on an electronic device **600**. In some embodiments, the display system enables viewing and comparing of data from two eyes of one patient across multiple tests and dates in a minimal amount of space. Accordingly, some embodiments enable the user to collapse undesirable test or date fields so as to maximize the display area of desired measurements.

Device **600** may be a portable computing platform, such as a smartphone or a tablet, or be a stationary computing platform with a display screen. Device **600** may allow touch screen operation, eye tracking operation where eye movements are interpreted as cursor movements on the device **600** itself or operation with standard computing peripherals such as a mouse and keyboard.

Data in the illustrated grid can be populated by software from a database of examination data that may, for example, include exams from many patients on many days. Accordingly, software running on device **600** can be configured to enable searching or selection of the patient whose exam data is to be displayed in the illustrated display configuration.

Software on device **600** can be configured to output exam data in a substantially tabular format comprised mainly of rows **612** and columns **614**. In various embodiments, the software can be configured to include all exam data for a given date in one column **614** while all measurements from a given test can be included in a single row **612**. The software can also enable preferences that allow transformation of this rule such that dates are in rows **612** and tests are in columns **614**. In some embodiments, each box in the table representing an intersection of a row **612** and a column **614** can be represented as a field populated with, for example, a numerical measurement, a text value, or an image. Although the fields are labeled generically in FIG. **6**, it will be appreciated that a variety of data, such as numbers, text, or images, can be displayed in each field.

Field **610** can be configured to contain information on the patient, such as name, date of birth, medical record number, age, gender. Although not illustrated here, field **610** may also be used to open pop-up windows that can be used to search or configure the exam display system.

Fields **620**-**625** can be configured to contain dates of exams for a given patient. In one embodiment, clicking of a column heading **620**-**625** toggles the column between collapsed and expanded configurations where data is not displayed in the collapsed configuration but data is displayed in the expanded configuration. In FIG. **6**, columns **620**, **623** and **625** demonstrate expanded fields while columns **621**, **622** and **624** represent collapsed fields. Thus, the fields in the collapsed columns **621**, **622**, **624** may be collapsed. For example, fields **650**, **651**, **652**, **653**, **654** may be collapsed when column **621** is collapsed. The software can be configured to allow users to toggle this display setting with, for example, a simple click of a column heading or other selection process.

Fields **630**-**634** can be configured to contain individual tests conducted on a given patient. In one embodiment, clicking of a row heading **630**-**634** toggles the row between collapsed and expanded configurations where data is not displayed in the collapsed configuration but data is displayed in the expanded configuration. In FIG. **6**, rows **63** land **634** demonstrate expanded fields while rows **630**, **632** and **633** represent collapsed fields. Thus, the fields in the collapsed rows **630**, **632**, **633** may be collapsed. For example, fields **640**, **650**, **660**, **670**, **680**, and **690** may be collapsed when row **630** is collapsed. The software can be configured to allow users to toggle this display setting with, for example, a simple click of a row heading or other selection process.

In FIG. **13**, it can be appreciated that two special rows can exist corresponding to the right (OD) and left (OS) eye headings. The software can be configured to collapse or expand all tests for a given eye when that row heading, such as OD or OS, is clicked or otherwise selected.

Referring to FIG. **13**, fields **641**, **644**, **671**, **674**, **691**, and **694** can be configured to display data, such as numbers, text or images. In one embodiment, display of images in these fields enables the user to click on the images to bring up a larger window in which to view the images. In another embodiment, display of numbers in these fields enables the user to click on the numbers to bring up a graph of the numbers, such as graph over time with the dates in the column headers as the x-axis and the values in the rows as the y values.

The software can be configured to show collapsed fields (e.g. field **640**, **650**, **660**, **651**, **661**) in a different color or in a different size. The software can also be configured to display scroll bars when fields extend off the display screen. For example, if more tests exist in the vertical direction than can be displayed on a single screen, the software can be configured to allow panning with finger movements or scrolling with, for example, vertical scroll bars. The software can be configured to enable similar capabilities in the horizontal direction as well.

As described above, in some embodiments, a mask **100** is configured to be interfaced with an ophthalmic device for performing an eye exam on a patient. In some embodiments, the ophthalmic device comprises an optical coherence tomography (OCT) device such as described above. An OCT device is operable to direct an incident light beam onto a patient's eye and receive a reflected or scattered light beam from the patient's retina. Three-dimensional images of eye tissue, such as the cornea, iris, lens, vitreous, or retina may be obtained by measuring reflected or scattered light from the tissue for example using Optical Coherence Tomography or other instruments. Many OCT devices employ beam-steering mirrors, such as mirror galvanometers or MEMS mirrors, to direct the light beam to an object of interest. Various OCT instruments comprise interferometers including light sources and optical detectors or sensors that receive light reflected or scattered from the eye and produce a signal useful for imaging the eye. One example of an OCT device is described above with reference to FIG. **12**.

When the mask **100** is interfaced with an OCT device for performing an eye exam, an incident light beam is transmitted through at least one of the optically transparent sections **124** of the mask **100** before impinging on the retina of the eye. A portion of the incident light beam may be reflected by the optically transparent sections **124** of the mask. Such reflection is undesirable as it decreases the amount of light transmitted to the retina of the eye and the reflected portion of the incident light beam may also reach the OCT device (e.g., the optical detector **518** therein) and may obscure the signal of interest, namely the reflected or scattered light from the retina. In some embodiments, to

ameliorate this problem, the optically transparent sections **124** of the mask **100** are coated with an anti-reflective coating configured to reduce reflection of the incident light beam by the optically transparent sections **124**. In various embodiments, the optical transparent sections **124** of the mask are configured to increase or maximize transmission of light, such as from an OCT device, and the proximal portions **154** and concaved rear surface **122** is configured to reduce or minimize transmission of light, such as ambient light or light not emanating from an OCT machine and may be opaque and include opaque sides. For example, the proximal portions **154** may have sides that are substantially non-transmissive to visible wavelengths. These sides may for example block 80-90%, 90-95%, 95-99%, and/or 99-100% of ambient visible light. Reduction of ambient light may for example assist in keeping the patients pupils dilated. Conversely, the optically transparent sections may have a transmittance of 70-80%, 80-90%, 90-95%, 95-99%, and/or 99-99.5%, or 99.5%-100% or any combination of these ranges in the wavelength range at which the ophthalmic device operates such as at 450 nm, 515 nm, 532 nm, 630 nm, 840 nm, 930 nm, 1060 nm, 1310 nm or any combination thereof or across the visible wavelength range, near IR wavelength range, or both these ranges or at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, or 90% of the visible range, near IR range, or both. In some embodiments, material (treated or untreated) such as plastic that is not substantially transparent to visible light or to many visible wavelengths but is transparent to infrared light may be employed, for example, as the window to the mask and possibly for at least part of the proximal portion (e.g., the sides). The window would thus potentially be able to transmit an IR probe beam from the ophthalmic device (e.g., OCT or SLO instrument) yet could block ambient visible light or a significant portion thereof thereby allowing the user's pupils when wearing the mask to be more dilated. In various embodiments, however, having a window having at least some wavelengths in the visible be transmitted through is useful for the wearer. In certain embodiments, the ophthalmic device operates at one or more near infrared wavelength. For example, the probe beam is in the near infrared. The window may therefore be transparent in at least at the NIR wavelength(s) at which the ophthalmic device operate, for example, at the probe wavelength. Optical coatings may be employed to impart these spectral characteristics on the mask (e.g., on the window).

In some embodiments, the anti-reflective coating is configured to reduce reflection of the incident light beam in a wavelength range that is comparable to the wavelength range of the light source used in the OCT device. For example, wide-spectrum sources such as superluminescent diodes, ultrashort pulsed lasers, swept source lasers, very short external cavity lasers, vertical cavity surface emitting lasers, and supercontinuum lasers can be used in OCT devices and could be used in other ophthalmic diagnostic and/or treatment devices. These light sources may operate in the visible and/or near infrared. For example, light sources that emit light in visible wavelengths such as blue, green, red, near infrared or 400-1500 nm may be used to image the eye. Accordingly, in some embodiments, the anti-reflective coating is configured to reduce reflection of the incident light beam in a wavelength range that is comparable to a visible spectrum. In some embodiments, the anti-reflective coating spans both a visible and invisible wavelength spectrum, operating at wavelengths such as 400 nm to 1500 nm, 450 nm to 1150 nm, 515 nm to 1100 nm or other regions. The anti-reflective coating may be strongly wavelength dependent or may be largely wavelength independent. Likewise, the anti-reflective coating may reduce reflection over a wide or narrow band. In some embodiments, the anti-reflective coating is configured to reduce reflection of the incident light beam in a wavelength band having a bandwidth ranging from about 5 nm to about 200 nm. In some embodiments, for example, this bandwidth may be between about 5 and 50 nm, 50 and 100 nm, 100 and 150 nm, 150 and 200 nm, 200 and 250 nm or larger. In some embodiments, the AR coating may operate across multiple bands that are separated from each other. Each of these bands may, for example, have a bandwidth, for example, as described above. The antireflective coating may reduce reflections at a normal incident angle to between about 5-10%, 3-5%, 1-3% or less. For example, with the anti-reflective coating, reflections at a normal incident angle may be reduced to 1 to 2% reflection, 0.5% to 1% reflection or 0.1% to 0.5% reflection, or 0.05% to 0.5% reflection, or 0.1% to 0.5% reflection, 0.1% to 0.01% reflection, or combinations thereof. In some embodiments, the amount of reflection may be higher or lower. In various embodiments, the anti-reflective coating operates on light from normal incidence up to oblique angles of incidence such as ±15 degrees, ±30 degrees or ±45 degrees.

The anti-reflective coating may comprise a multi-stack optical structure and, in particular, may comprise an interference coating such as a quarter-wave stack. The anti-reflective coating may comprise, for example, one or more layers having a thickness of a quarter or half wavelength of the light and accomplish reflection reduction through destructive interference. Other types of anti-reflection coatings may be employed.

FIG. **14** illustrates a mask **200** for performing an eye exam according to an embodiment. The mask **200** includes a distal sheet member (distal portion) **218** and a proximal member (proximal portion) **254** coupled to the distal portion **218**. The distal portion **218** has one or more substantially optically transparent sections **224**. The proximal portion **254** has a rear surface **222** that faces the patient's face when in use, and is configured to conform to contours of the patient's face and align the one or more substantially optically transparent sections **224** of the distal portion **218** with the patient's eyes. The distal portion **218** can be configured to be optically interfaced with a docking portion of an ophthalmic device such as an OCT instrument. The ophthalmic device is operable to direct an incident light beam such as a probe beam onto and/or into a patient's eye and receive a reflected or scattered light beam from the patient's eye. The docking portion of the ophthalmic device includes an optical interface such an optically transparent window or plate for transmitting the incident light beam therethrough and incident on the optically transparent sections **224** of the distal portion **218**. The docking portion may also include a slot in which a flange on the mask fits into. In some embodiments, the ophthalmic device comprises an optical coherence tomography device although the ophthalmic device may comprise other diagnostic instruments or devices such as a scanning laser ophthalmoscope (SLO).

In some embodiments, to reduce retro-reflection back into the ophthalmic device, at least one of the optically transparent sections **224** of the mask has at least a portion thereof that is tilted or sloped with respect to the incident light beam when the distal sheet member **218** is optically interfaced with the docking portion of the ophthalmic device. In such embodiments, the incident light beam forms a finite (non-zero) angle of incidence with respect to the corresponding portion of the mask. If the finite angle of incidence is

sufficiently large, a retro-reflected light beam may be prevented from being retro-reflected back into the oculars of the ophthalmic device. In some embodiments, the magnitude of the tilt or slope angle is in a range from about 1 degree to about 30 degrees. In some embodiments, the magnitude of the tilt or slope angle is greater than about 1 degrees, 2 degrees, 4 degrees, 5 degrees, 6 degrees, 8 degrees, 10 degrees, 15 degrees, 20 degrees, 25 degrees, 30 degrees, 35 degrees, 40 degrees, 45 degrees, 50 degrees, 55 degrees, and less than 60 degrees, 55 degrees, 50 degrees, 45 degrees, 40 degrees, 35 degrees, 30 degrees, 25 degrees, 20 degrees, 15 degrees, 10 degrees, or 5 degrees or any combination thereof. For example, the magnitude of the slope may be greater in magnitude than 30° and less than 35° or greater than 1° in certain portions and less than 35° or 40°. This tilt or slope angle may be measured between a central axis through the optical path from the ophthalmic device (e.g., OCT instrument) to the mask and the normal to the surface of the optically transparent section **224** of the mask where that central axis or probe beam is incident. In some embodiments, this angle may be measured, for example, with respect to the optical path from the ophthalmic device (e.g., OCT or SLO instrument) or optical axis of the ophthalmic devices, for example, from the exit pupil of left or right channel of the OCT or SLO instrument, an optical axis of an optical element (e.g., left and/or right ocular lens, eyepiece, or channel) associated with an ophthalmic device through which the beam passes prior to output from the ophthalmic devices, as well as from a normal to a transparent interface (e.g., a window or ocular lens) on the ophthalmic device. In addition, this angle may be measured with respect to the normal to the surface on the optically transparent section **224** of the mask where the beam or center thereof or central axis therethrough from the ophthalmic instrument would be incident on the optically transparent section **224**. Similarly, this angle may be measured with respect to the mask's forward line of sight when worn or the line of sight of a wearer of the mask. A standard anatomical head form such as an Alderson head form may be used to determine the line-of-sight through the mask. Accordingly, the angular ranges described above may be measured between the line-of-sight of a Alderson head form when the mask is placed on the head form as would be worn by a wearer (in the as worn position) and the normal to the surface of the optically transparent section **224** of the mask at the location that the normal line-of-sight of the head form intersects or passes. Other approaches to measuring the angle may also be used.

In various embodiments, the shape of the rear surface **222** is determined from measurements taken from at least one magnetic resonance imaging (MRI) scan of a human head. Segmentation of the surface of one or more faces (e.g., at least 10, 20, 30, 100, to 200, 500, 1000, or more faces) obtained from MRI images can be used to determine a contour that is substantially conformed to by the rear surface **222**. Statistical processes can be applied to these sets of MRI images to produce average face contours, median face contours, or face contours that match a certain percentage of the population, such as 95%, 99%, or 99.5%. These MRI images can also be used to define the line-of-sight through the mask. Standard lines defined by MRI images of the human head, such as the eye-ear line extending from the center of the ear canal to the lateral canthus where the eyelids join or a line in the Frankfurt plane extending from the center of the ear to the lowest portion of the eye socket, can be used to define the direction of the line-of-sight through the mask with a rear surface **222** defined by these same MRI images. Other lines, such as a line that connects the pupillary center and macular center as seen by MRI could also be used. The placement of the line-of-sight on the optical transparent section **224** may also be defined by measuring the distance between the pupils, the interpupillary distance (IPD), on the MRI images.

In various embodiments, the probe beam raster scanned across the tissue to obtain OCT signals over a region of the eye. As described above, to accomplish such raster scanning, the direction of the probe beam may be swept using, for example, a MEMS mirror. FIG. **15**A illustrate an arrangement where a probe beam is reflected off a beam steering mirror through the mask window into the eye. The beam steering mirror can be rotate back and forth to sweep the beam through a range of angles and through a range of positions in and/or on the tissue being images or evaluated. FIG. **15**A show both the optical path of the probe beam as well for light scattered from the tissue that returns back through the OCT instrument. As discussed above, in some instances, reflections from the mask window are retro-reflected and thus also return to the sensors used in the OCT instrument. With the normal to the window oriented at 0° with respect to the incident probe beam, light is reflected from the window back into the OCT instrument as shown in FIG. **15**A. This retro-reflected light introduces noise into the signal comprising scatters light from the tissue, which could be a weak signal. The back reflection thus decreases the signal to noise ratio and makes obtaining an image more difficult.

To improve the signal to noise ratio, the window can be tilted an angle with respect to the beam. This tilt angle may be β degrees. The result is that the retro-reflected beam will be tilted such that the beam cannot enter back into the OCT instrument disrupting the signal. As illustrated in FIG. **15**B, for a given ophthalmic instrument such as an OCT instrument, there is an angle, Δ, of the retro-reflected beam (measured with respect to the incident beam or the incident optical path) at which the reflected beam is unlikely to not enter back into the OCT instrument and introduce noise onto the OCT signal. This angle Δ may depend in part on the beam size, the size of the optics in the OCT instrument, e.g., the beam steering mirror, as well as the relative location of the optics longitudinally along the optical path. This angle may be for example, 0.5° to 1°, 1° to 2°, 2° to 3°, or combinations thereof.

In various embodiments, as illustrated in FIG. **15**C, the optics in the ophthalmic instrument are configured such rays of light from the probe beam exiting the exit pupil or ocular of the ophthalmic instrument are generally converging. For example, the probe beam may substantially fill the exit pupil of the ophthalmic instrument and be focused down. Such approach may be referred to as a flood illumination. In addition, as described above, in some embodiments, a beam having a beam width narrower than the aperture of the ocular or exit pupil of the ophthalmic instrument is swept through a range of angles. This approach may be referred to as beam steering. In both cases, light rays may be incident on the mask at a range of angles, for example, defined by a cone angle (α). This range of angles may be determined, for example, by the F-number or numerical aperture of the output of ophthalmic device such as the ocular lens or focusing lens of the ophthalmic device and/or by the movable mirror (MEMS mirror). This range of angles may also correspond to the range of angles that the ophthalmic device will collect light. For example, rays of light reflected back into this range of angles, may be collected by the ophthalmic instrument and contribute to the signal received. This col-

lection angle may also be determined by the F-number or numerical aperture of the ocular of the ophthalmic device (e.g., OCT instrument).

In some embodiments, the tilt or slope angle of the optically transparent section **224** of the mask is configured to be greater than the largest angle of incident light produced by the OCT or other imaging or ophthalmic device. For example, if an accompanying ophthalmic (e.g., OCT) device, because of beam steering or flood illumination, produces light rays between −30 degrees and +30 degrees with respect to the optical axis of the ophthalmic device or with respect to the central axis of the optical path from the ophthalmic device to the mask (e.g., a cone angle α of 30°), the magnitude of the tilt or slope angle (β) of the optically transparent section **224** of the mask can in various embodiments be greater than the cone angle, for example, more negative than −30 degrees or more positive than +30 degrees. For example, the tilt or slope angle, β, may be less than −30° (e.g., −31°, −32° etc.) or greater than +30° (e.g., 31° or more).

FIGS. **15**C-**15**E show how tilting the optically transparent section **224** reduces the likelihood that light exiting the ophthalmic device will be retro-reflected back into the ophthalmic device.

FIG. **15**C, for example schematically illustrates a planar window **224** on the mask corresponding to the optically transparent section **224** that does not have an AR coating. The window **224** is shown receiving a bundle of rays **265** of light that are focused down by a focusing lens **270** at the output of the ophthalmic device. This focusing element **270** may be a lens (e.g., in an ocular) that outputs a focused beam of light from the ophthalmic device (e.g., OCT instrument). The focused bundle of rays **265** is show centered about a central axis **267** of the optical path from the ophthalmic device to the mask that corresponds to an optical axis **267** of the ophthalmic device (e.g., the optical axis of the focusing lens **270**). The focused bundle of rays **265** may correspond to rays of light simultaneously provided with flood illumination or rays of light sweep through the range of angles over a period of time by the beam steering optics (e.g., movable mirror). FIG. **15**C illustrate how, in either case, the bundle of rays **265** propagating along the optical path from the ophthalmic instrument to the eye can be reflected back toward the ophthalmic device at an angle within the collection angle defined by the numerical aperture of the lens **270** such that this light would propagate back along the same path to the ophthalmic device and re-enter the ophthalmic device possibly interfering with the signal.

FIG. **15**D, for example schematically illustrates a planar window **224** on the mask having an AR coating thereon. Accordingly, the rays of light reflected from the mask window **224** are shown attenuated as back reflection is reduced by the AR coating.

FIG. **15**E, for example schematically illustrates a planar window **224** on the mask without an AR coating that is tilted or sloped such that the normal (shown by dotted line) to the window is disposed at an angle, β, with respect to the central axis **267** of the optical axis from the exit pupil or ocular/eyepiece of the ophthalmic device to the window. The mask window receives a bundle of rays **265** of light (either simultaneously during flood illumination or more sequentially in a beam steering approach) focused down by a focusing lens **270** at the output of the ophthalmic device. The maximum ray angle or cone angle of the focused bundle of rays **265** is shown as α. In this example, $|\beta|>\alpha$, where α is the cone angle measured as a half angle as shown. In various embodiments, $|\beta|-\Delta>\alpha$. As discussed above, Δ is the angle at which the probe beam can be offset with respect to the probe optical path so as not to be coupled back into the OCT instrument via retro-reflection and thereby disrupt the OCT signal by introducing noise. (See FIG. **15**B.) Accordingly, rays in the bundle of rays **265** propagating along the optical path from the ophthalmic instrument to the eye are not reflected back toward the ophthalmic device at an angle within the collection angle defined by the numerical aperture of the lens **270** such that this light does not re-enter the ophthalmic device. Tilting or sloping the window **224** sufficiently beyond the angle of the steepest ray of light from the probe beam can reduce retro-reflection. As discussed above, in various embodiments, the magnitude of the tilt or slope angle β is larger than the cone angle α, where α is the cone angle measured as a half angle as shown and is a positive value, or the magnitude of the tilt or slope exceeds the angle of the ray **268** exiting the ophthalmic device (e.g., exiting the ocular lens **270** shown in FIG. **15**E) that is incident onto the mask window at the largest angle providing greater deflection away from the optical axis **267** for that ray **268**. Accordingly in various embodiments, $|\beta|>\alpha$ thereby increasing the amount of rays that are not retro-reflected back through the lens **270** and into the ophthalmic device. As discussed above, in various embodiments, $|\beta|$ exceeds α by at least Δ. The magnitude of the tilt or slope angle β of the optically transparent section **224** may thus be greater than the cone angle α established by the f-number or numerical aperture of the ophthalmic device. In some embodiments, one or more of these relationships are true for 50-60%, 60-70%, 70-80%, 80-90%, 90-95%, 95-98%, 98-99%, or 99-100% of the light from the probe beam (e.g., as rays are swept through the range of angles to provide raster scanning). Combinations of these ranges are also possible.

In addition to being tilted or sloped, the optically transparent sections **224** may also be coated with an anti-reflective coating as described above. In some embodiments, the respective portion of the optically transparent sections **224** is tilted or sloping upward or downward, as illustrated in FIGS. **14**A-D. In other embodiments, the respective portion of the optically transparent sections **224** is tilted or sloped temporally or nasally, or in a combination of upward/downward and nasal/temporal directions.

FIGS. **16**A-D illustrate a mask **300** for performing an eye exam according to an embodiment. The mask **300** is similar to the mask **200** shown in FIG. **14**, except that two of the one or more substantially optically transparent sections **224***a* and **224***b* are tilted or sloped temporally or nasally in opposite directions with respect to each other. In an embodiment, the two substantially optically transparent sections **224***a* and **224***b* are tilted or sloped symmetrically away from the nose and nasal lines or centerline. In other embodiments, combinations of tilt directions are possible. For example, according to some embodiments, one optically transparent section **224***a* is tilted or sloped upward or downward, and the other optically transparent section **224***b* is tilted or sloped nasally or temporally. In some embodiments, a portion of the optically transparent sections **224** that intersect the incident light beam is planar, as illustrated in FIGS. **14** and **15**. In other embodiments, a portion of the optically transparent sections **224** is curved, as discussed below.

FIGS. **17**A-**17**C, for example, illustrate how curved windows **224** can be used as the optically transparent sections **224** of a mask and the effect of such curved windows on an incident probe beam **265**. In certain embodiments, depending on the placement of the incident beam **265** with respect to the mask window **224**, the window may provide a perpendicular surface for many of the rays of light in the

beam thereby causing retro-reflection back into the channels of the ophthalmic instrument thereby contributing to noise in the signal.

FIG. **17**A, for example, shows a curved window **224** without an AR coating having a center of curvature **272** that is located at the focus point **274** of the optics **270** of the ophthalmic device. Such alignment can cause a significant portion of the light to be retro-reflected back into the ophthalmic device. The focus point **274** of the optics **270** in the ophthalmic device may comprise the focal point of the lens or optics in the ophthalmic system (e.g., in the ocular or eyepiece or left or right output channel).

FIG. **17**B shows a curved window **224** without AR coating having a center of curvature of the window that is behind or beyond the focus point of the lens **270**. This positioning may be determined in part by the mask and the interconnection between the mask and the ophthalmic device that establishes the spacing between the ophthalmic device and the eye of the subject wearing the mask. In FIG. **17**B, rays of light are retro-reflected back toward the ophthalmic device at an angle within the collection angle defined by the numerical aperture of the lens **270** such that this light re-enters the ophthalmic device.

In contrast, FIG. **17**C shows a curved window **224** without AR coating having the center of curvature that is in front of the focal point **274** of the optics. As discussed above, this positioning may be determined in part by the mask and the interconnection between the mask and the ophthalmic device that establishes the spacing between the ophthalmic device and the eye of the subject wearing the mask. Some of the rays on the outer parts of the cone of rays **265**, including the ray **268** directed at the largest angle are not retro-reflected back toward the ophthalmic device at an angle within the collection angle defined by the numerical aperture of the optics **270** such that this light does not re-enter the ophthalmic device. However, rays closer to the optical axis **267** are closer to being perpendicular with the normal of the window such that those rays are retro-reflected back toward the ophthalmic device at an angle within the collection angle defined by the numerical aperture of the optic **270** and thus re-enter the ophthalmic device. In various embodiments where the ophthalmic device is a beam-scanning device such as an OCT device or a scanning laser ophthalmoscope, a small offset angle between the cone of rays **265** and the slope of the curved window **224** is sufficient to sufficiently reduce or prevent retro-reflection of light into the ophthalmic device.

FIGS. **17**D and **17**E schematically illustrate shifts of the center of curvature of the window to the left and the right. FIG. **17**D shows a curved window **224** without AR coating having a center of curvature of the window that is to the left of the focus point and optical axis **267** of the lens **270**. This positioning may be determined in part by the mask and the interconnection between the mask and the ophthalmic device that establishes the spacing and positioning between the ophthalmic device and the mask as well as the eye of the subject wearing the mask. In FIG. **17**D, rays of light that intersect the curved window **224** to the right of its center of curvature are retro-reflected at an angle that is substantially directed away from the lens **270** and the optical axis **267**. Light that intersects the window **224** to the left of its center of curvature is retro-reflected back toward the ophthalmic device at an angle within the collection angle defined by the numerical aperture of the lens **270** such that this light re-enters the ophthalmic device.

Similarly FIG. **17**E shows a curved window **224** without AR coating having a center of curvature of the window that is to the right of the focus point and optical axis **267** of the lens **270**. As discussed above, this positioning may be determined in part by the mask and the interconnection between the mask and the ophthalmic device that establishes the spacing and positioning between the ophthalmic device and the mask as well as the eye of the subject wearing the mask. In FIG. **17**E, rays of light that intersect the curved window **224** to the left of its center of curvature are retro-reflected at an angle that is substantially directed away from the lens **270** and the optical axis **267**. Light that intersects the window **224** to the right of its center of curvature is retro-reflected back toward the ophthalmic device at an angle within the collection angle defined by the numerical aperture of the lens **270** such that this light re-enters the ophthalmic device.

In these examples, the windows **224** are spherical. In other embodiments, however, the window **224** may have a curved surface other than spherical, e.g., aspheric surface curvature. In addition to being tilted or sloped, the curved optically transparent sections **224** may also be coated with an anti-reflective coating as described above.

FIGS. **18**A-D illustrate a mask **300** for performing an eye exam similar to the mask **200** shown in FIG. **14**, except that two of the one or more substantially optically transparent sections **224***a* and **224***b* are curved. In particular, the substantially optically transparent sections **224***a* and **224***b* have outer surfaces as seen from the front of the mask having a convex shape. These curved surfaces may be spherical in shape or may be aspherical. For example, the curved surfaces may be an ellipsoidal surface or an oblate spheroid surface, or have a shape characterized by a higher order polynomial or be combinations thereof. Other shapes are possible. In various embodiments, the surface is more flat at the center of the substantially optically transparent section and curves or slopes more steeply away from the center of the substantially optically transparent section as shown by FIGS. **18**A-D. In some embodiments, the mask has a size and the substantially optically transparent sections are disposed such that the flatter central portions of the substantially optically transparent section are along the line of sight of the wearer. Accordingly, in various embodiments, the surface is flatter closer to the normal line of sight and slopes more steeply away from the normal line of sight.

Various embodiments of masks having optically transparent sections **224***a* and **224***b* that are curve and may be plano and have negligible optical power. Not having optical power will likely contribute to the comfort and viewing experience of the wear. Accordingly, optically transparent sections **224***a* and **224***b* may have anterior and posterior surfaces having shapes that together provide that the optically transparent sections **224***a* and **224***b* have substantially zero diopters of optical power. In some embodiments, however, the optically transparent sections **224***a* and **224***b* may have optical power such as to accommodate individuals who need refractive correction.

In some embodiments, the angle of incidence varies across transparent section **224**. A curved window **224** depending on the shape and/or position with respect to the focus of the probe beam may cause the angle of incidence to vary across the transparent section **224**.

FIG. **19** schematically illustrates a window **224** of a mask disposed in front of a pair of eyes such that most of the rays of light from the incident beam are reflected at angles beyond the collection angle within the numerical aperture of the optics **270** or exceeds than an offset angle Δ described above for beam-scanning devices. Accordingly, most of the light does not re-enter the ophthalmic device. In particular,

the window **224** is sloped except for at the centerline where the nose of the wearer is located. Additionally, the window has a slope that increases in magnitude temporally. Moreover, the window is sloping such that all the rays in the cone of rays **265** of the incident beam are directed temporally upon reflection (unlike in the examples shown in FIGS. **17**A-C).

In the example shown in FIG. **19**, the window **224** has a slope and curvature that increases in magnitude temporally such that the slope or curvature is maximum at the periphery or edges **273** of the window **224**. This slope or curvature at the location of the line of sight (e.g., within a range of interpupillary distances between 50-80 mm or 25-40 mm from the centerline) is sufficiently high in magnitude to exceed the angle of the ray **268** exiting the ophthalmic device (e.g., exiting the ocular lens **270**) at the largest angle that is incident onto the mask window **224**. Additionally, the slope or curvature of the window **224** is sufficiently high in magnitude to deflect all or substantially all or at least most of the other rays away from the optical axes **267** of the output channels of the ophthalmic device. At each point where rays from the probe beam intersect the window **224**, the normal to the window surface is oriented with respect to the cone of rays **265** to deflect the ray outwards or to retro-reflect the probe beam at an angle Δ described previously for beam-scanning devices. Moreover, the rays are deflected sufficiently so as not to be retro-reflected at an angle within the collection angle defined by the numerical aperture of the output channel of the ophthalmic device such that this light is not coupled back into the ophthalmic device so as to interfere with the signal (e.g., the OCT signal).

Additionally, in various embodiments, the width of this curved window **224** may be sufficient to account for the lateral position and movement of the oculars or output channels of the ophthalmic device. Increasing the interpupillary distance of the pair of output channels of the ophthalmic device effectively pushes the outermost ray **268** more temporally. Accordingly, the width and curvature of the window **224** on the mask can be established to ensure that half, or most, or substantially all, or all the rays of light from the left and right output channels of the ophthalmic instrument are at a given instant in time or over the range of angles swept during a raster scan not incident on the mask window at an angle where the rays are retro-reflected back at an angle within the collection angle defined by the numerical aperture of the channels such that the light is collected by the channels and introduces noise to the signal. For example, if the angle of the ray **268** exiting the left and right channels of the ophthalmic device at the largest angle is 35 degrees (e.g., if the cone angle α is ±35°), and the maximum lateral position of those rays is 40 mm from the centerline **279** or nose line on the window of the mask, a shape can be configured for the window that ensures that none or substantially none of the rays are incident on the transparent window in a perpendicular orientation and instead cause most, all, or substantially all the incident light to deflect outside the collection angle defined by numerical aperture of the left and right channels of the ophthalmic devices.

As discussed above, the substantially optically transparent sections **224***a* and **224***b* have outer surfaces as seen from the front of the mask having a convex shape and are aspherical. For example, the curved surfaces may be ellipsoidal, toroidal, or have a shape characterized by a higher order polynomial or combinations thereof.

Additionally, in various embodiments the optically transparent sections **224***a* and **224***b* are plano and have negligible optical power. The optically transparent sections **224***a* and **224***b* may have anterior and posterior surfaces having shapes that together provide that the optically transparent sections **224***a* and **224***b* has substantially zero diopters of optical power. In some embodiments, however, the optically transparent sections **224***a* and **224***b* may have optical power to accommodate individuals who need refractive correction.

Moreover, the transparent section **224** can be comprised of a curved transparent outer surface sufficiently sloped such that the angle of incidence of the rays of light output by an accompanying OCT machine when interfaced with the mask is not normal to the transparent section **224** at most or substantially all the points of incidence on transparent section **224** and the slope or tilt is configured to deflect the rays away from the optical axis and outside the collection angle of the OCT machine (e.g. $|\beta|>\alpha$). In some embodiments, such as beam-steering optical devices, the difference between angle $|\beta|$ and angle α is be greater than an angle Δ such that $|\beta|-\Delta\geq\alpha$ to prevent any retro-reflected beam from impinging on the beam-steering device, such as a galvanometric mirror or MEMS mirror, and being sensed by the device. In some embodiments, this relationship is true for 50-60%, 60-70%, 70-80%, 80-90%, 90-95%, 95-98%, 98-99%, or 99-100% of the light from the probe beam as used (e.g., flood illumination or swept) to generate images by the ophthalmic device or combinations of these ranges.

Accordingly, in various embodiments, only 3-5% or 2-4%, or 1-3% or 0.5-1% or 0.1-0.5% or 0.05-0.1% or 0.01-0.05% of the light is reflected back into the ophthalmic device.

FIGS. **20**A-D schematically illustrate a mask **300** for performing an eye exam having transparent sections **224** with curvatures such as shown in FIG. **19**. Accordingly, the optically transparent sections **224**, sometimes referred to herein as an optically transparent region, mask window or curved transparent section, have wrap and sweep back progressively with distance from a centerline of the mask (nasal line) **273** where the nose of the wearer would be positioned. Additionally, the mask window also has curvature in the superior-inferior meridian. Accordingly, this mask may reduce retro-reflection of light from the optical coherence tomography instrument back into the instrument.

In some embodiments, the curved transparent section **224** extends across all of distal portion **218**. In some embodiments, curved transparent section **224** is only a portion of distal portion **218** (e.g., see FIGS. **21**A-**21**D in which the optically transparent section does not extend to or is displaced from the lateral edges of the mask). As shown, the mask has a front sheet that sweeps backward (e.g., posterior) and outward (e.g., lateral) from the centerline **279** and provides suitable curvature to reduce reflection back into the OCT instrument and thereby reduce noise on the OCT signal.

In certain embodiments for example, the mask includes left and right substantially optically transparent sections **224***a*, **224***b* disposed on left and right sides of the centerline **273**. The left and right substantially optically transparent sections **224***a*, **224***b* may be disposed with respect to each other to accommodate interpupillary distances (see FIG. **19**) between about 50-80 mm, for example, for adults. Accordingly, the distance between the normal line of sight and the centerline (which can be centered on the nose of the patient) is about 25-40 mm. In some embodiments, at least the right substantially optically transparent section **224***a* (or the left section **224***b* or both) has at least a portion thereof that is sloped such that at a location on the right substantially optically transparent section **224***a* (left section **224***b* or both)

that is 30 mm from the centerline (e.g., lateral of the superior inferior meridian), the right substantially optically transparent sections is sloped by at least 10° or more, at least 20° or more, at least 30° or more, at least 40° or more, at least 50° or more up to 70° or 80° or 90°, with respect to a line through that location that is parallel to the centerline. This angle may be established by the cone angle α discussed above and can have a magnitude greater than 10° such as more than 15°, 20°, 25°, 30°, 35°, 40°, 45°, 50°, 55°, 60°, up to 70° or 80° or 90° etc. The right substantially optically transparent section (or left section or both) may have the same slope magnitude or be increasingly sloped (for example, have a magnitude greater than for example 10°, 15°, 20°, 25°, 30°, 35°, 40°, 45°, 50°, 55°, 60°) at locations progressively more temporal from the location (e.g., greater than 30 mm in distance from the centerline) at least to about 35 mm or 40 mm etc. from said centerline. In some embodiment, the location can be 20 mm, 22.5 mm, 25, mm, 27 mm, 29 mm, 31 mm, 33 mm, 35 mm, 37 mm, 39 mm, or any range therebetween. In some embodiments, at 25 mm from the centerline, the magnitude of the slope may be greater than for example 10°, 15°, 20°, 25°, 30°, 35°, 40°, 45°, 50°, 55°, 60° and/or the slope may exceed the cone angle such that the outermost ray of light from the ocular in the ophthalmic instrument is deflected away from the optical axis of the ocular. Likewise, for locations progressively more temporal, the optically transparent section may be sloped (for example, may have a slope with magnitude greater than for example 10°, 15°, 20°, 25°, 30°, 35°, 40°, 45°, 50°, 55°, 60°), may have constant slope, or varying slope, e.g., increasingly sloped. Additionally, in some embodiments, the right (left or both) substantially optically transparent section(s) is sloped by at least 15°, 17°, 19°, 21°, 23°, 25°, 27°, 29°, 31°, 33°, 35°, 37°, 39°, 41°, 43°, 45°, 47°, 49°, 51°, 53° or 55°, in magnitude at said location or ranges therebetween. Accordingly, in some embodiments the substantially optically transparent section sweeps back as illustrated in FIG. **19**.

Likewise, the window exhibits wrap. In some embodiments, the window wraps at least partially around the side of the face or at least begins to wrap around the side of the face. This curvature is desirable where the rays of light from the ophthalmic instrument might intersect the optically transparent window. Since different subjects will have different interpupillary distances, and the ophthalmic instrument may be adjusted accordingly to direct the probe beam through the pupil of the eye, the rays from the probe beam may be incident over a range of locations on the substantially optically transparent sections. A window that exhibits wrap over a region thereof may thus be desirable to reduce retro-reflection back into the instrument. In various embodiments, windows that sweep rearward with distance progressively more temporal of the centerline **273** of the mask **300** are useful in deflecting light temporally and outside the collection angle of the ophthalmic device. The slopes may be substantially constant in the temporal region or may be varying.

Although FIG. **19** is a useful reference for the discussion above where curvature is shown along a nasal-temporal meridian, in considering the superior-inferior meridian, reference to FIGS. **17**A-E may be beneficial. In various embodiments, the window is curved along the superior-inferior meridian. This curvature as well as the distance of mask from the ocular on the ophthalmic instrument (as established by the mechanical interface between the mask and the ophthalmic device) may be such that a plurality of, many, possibly most, or substantially all rays in the bundle of rays from the ocular are deflected upward or downward and outside the collection angle of the ocular.

In various embodiments, combinations of tilt directions and curvature of transparent sections are possible. FIGS. **21-27** and **29**A-**29**C show additional designs having differently shaped windows. FIGS. **21**A-D as well FIGS. **26** and **27** schematically illustrate a design having a planar portion **291** of the substantially transparent section that is located more nasally and an adjacent planar sloping portions **293** located temporally. A transition **295** between these portions **291**, **293** is curved. In certain embodiments, this transition **295** has a curvature of a circular arc having a center and radius of curvature. The sloping portions may slope along a nasal-temporal direction, for example, by at least as much as the right and left substantially optically transparent sections **224***a*, **224***b* described above. Curvature or slope in the superior-inferior direction is negligible. FIGS. **29**A-**29**C illustrate another mask **300** with a substantially transparent section **224** having a profile similar to that shown in FIGS. **21**A-**21**D except that the lateral edges of the substantially transparent section **224** extend to the lateral edges of the cushion **305**. Additional discussion regarding this design is provided below in connection with FIGS. **28**A-D.

FIGS. **22-24** and **25**A-D (as well as **39**A-D and **40**A-D) show transparent sections that are curved in both nasal-temporal meridian and superior-inferior meridian. (FIGS. **22** and **23** show the same compound curved surface as in FIG. **24**.) In various embodiments such as shown in FIG. **25**B, the curvature or slope of the substantially transparent section **301** in the nasal-temporal direction is negligible closer to the centerline until reaching a temporal location where the magnitude of the slope increases temporally to generate a curved temporal section that sweeps backward. The slope can, for example, be at least as much as the right and left optically transparent sections **224***a*, **224***b* described above. The curvature or the magnitude of the slope of the substantially transparent section **301** along the superior-inferior meridian starts out high in magnitude at the inferior location, reduces in magnitude to a negligible amount halfway between the inferior and superior extent of the convex shaped substantially transparent section **301** and increases again at the superior locations. The curvature is such that the magnitude of slope increases with increasing distance superiorly and inferiorly beyond the central flat non-sloping region. The curvatures do not slope or the slope is substantially negligible along the nasal temporal meridian in this central flat non-sloping region as well. In various embodiments this central flat non-sloping region can be ⅛, ⅙, ¼, ⅓ or ½ to ¾ or values in any range formed by any of these values the extent of the convex shaped substantially transparent section along the nasal temporal meridian, the superior inferior meridian, or both. In other embodiments, the curvature of the substantially transparent section **301** is equal in both the nasal-temporal meridian and the superior-inferior meridian at any given point on the surface of the transparent section **301** such as with a spherical surface. In some cases, enhanced or maximum deflection of the back reflected OCT beam is obtained when the curvatures in the two meridians are equal such as for a spherical surface where the radius of curvature in one meridian is equal to the radius of curvature in the perpendicular meridian. A spherical surface has the same amount of drop with distance laterally as with movement in position inferiorly or superiorly. In contrast, in various other embodiments, such as for an ellipsoid or paraboloid surface, the curvature in the two meridians is different. For an ellipsoidal, toroidal or paraboloid surface, the curvature is steeper in one meridian than

another. When the curvature is the same in orthogonal meridians, however, such as with a spherical surface, the amount of light that is deflected away from being scattered back into the OCT machine can be increased or maximized while distortion (e.g., pin cushion distortion or astigmatism) is reduced or minimal. In various configurations, the outer surface and the inner surface are curved and have the same curvature but different centers of curvature. In certain configurations, the curvature of both the outer surface and the inner surface are defined by the same center of curvature, e.g., the curvatures have different radii of curvature and the same center of curvature. Accordingly, as discussed above, in certain configurations the thickness remains substantially constant across the transparent window or large portions thereof that provide access of the OCT beam to the user's eye. Such constant thickness can reduce aberrations such as, for example, astigmatism. In other configurations, the thickness varies across the transparent window or large portions thereof that provide access of the OCT beam to the user's eye. Such varying thickness can increase stiffness and rigidity.

In various embodiments, one or more of the optically transparent regions can be plano and not have optical power. In some embodiments, however one or more of optically transparent section can have optical power at least in one meridian. In certain embodiments wherein the front and rear surface of the optically transparent section have offset centers that provide astigmatism, the optically transparent section has optical power in at least one of the meridians.

FIGS. **28**A-D illustrate some of the design considerations entailed in various embodiments of the mask window. For certain ophthalmic instruments, different modes of operation may involve use of probe beams with different characteristics.

FIG. **28**A for example, illustrates a mode of operation where an OCT instrument is configured to output a planar non-focused wavefront. Optics in the OCT instrument are configured to be telecentric. FIG. **28**A therefore shows on a plot of angle of incidence (in degree) versus distance (in mm) from the centerline, the output from the ocular or eyepieces for the left and right channels of the ophthalmic device (e.g., OCT instrument). The plot shows an angle of 0° for each of the rays across the aperture of the ocular for both the left and right channels.

FIG. **28**B illustrates a mode of operation where an OCT instrument is configured to output beam that sweeps across a range of angles α as discussed above. A plot of angle of incidence (in degree) versus distance (in mm) from the centerline shows the output of the ocular or eyepieces for the left and right channels of the ophthalmic device (e.g., OCT instrument). These plots show the change in angle for the different rays across the aperture of the ocular for both the left and right channels.

The OCT instrument is configured to provide modes of operation using probe beams characterized by the plots shown in FIGS. **28**A and **28**B. Accordingly, in various embodiments, a mask that can reduce retro-reflection back into the OCT system for both of these modes is beneficial. The signal-to-noise ratio can thereby be increased by curtailing introduction of noise into the signal by retro-reflection off the mask. Accordingly, FIG. **28**C shows the combination of angles of incidence in the probe beam for the two modes on a single plot.

FIG. **28**D presents a solution for reducing retro-reflection. As discussed above, rays perpendicularly incident on the mask will be retro-reflected back into the OCT instrument and introduce noise to the OCT signal. However, by adding a slight offset Δ to the reflected beam such that the beam is not incident perpendicular on the mask and does not reflect directly back in the same direction the amount of rays that return back into the OCT instrument can be reduced. The plot in FIG. **28**D shows the addition of this offset. In particular, an offset of 1° has been provided.

In this example, the inter-optical distance, the distance between the centers or optical axes of the oculars or eyepieces, which is related to the interpupillary distance of the subject, was 54 mm. Accordingly, a line of sight for wearers would be expected to be at 27° in both directions from the centerline for each of the left and right eyes. The magnitude of the slope of the mask is therefore set to increase continuously in the regions between 27 mm and about 38 mm where the magnitude of the slope reaches a maximum (just beyond the angle of the outermost ray in the bundle shown in FIGS. **28**A and **28**B). This curvature is to address the mode of operation represented by FIG. **28**B. The small 1° in the region between 0 mm and 27 mm is to address the mode of operation represented by FIG. **28**A where the rays are each at an angle of incidence of 0° without the offset. FIG. **28**D shows a cross-section of the mask. The cross-section shows a wide central region **291** between for the right eye between 0 and 27 mm without a large amount of slope, a transition region **295** between 27 mm and 38 mm where the magnitude of the slope is increasing, and a region **293** from 38 to 49 mm where the slope magnitude remains constant. A similar shape could be used for the left eye thereby providing a symmetrical configuration.

Other variations are possible. For example, in one embodiment, for the right eye, the magnitude of the slope at 27 mm could be set to be so large as to account for $\alpha+\Delta$, namely, $\beta \geq \alpha+\Delta$ at 27 mm. The transition region **295** could thus start around 13 or 14 mm and be complete by 27 mm where the magnitude of the slope could remain constant for distances beyond 27 mm (e.g., in region **293**). In the region **291** between 0 to 13 or 14 mm, the small slope offset of 1° or so could be introduced. A similar shape could be used for the left eye thereby providing a symmetrical configuration.

The various shaped windows may further include an AR coating as discussed above.

As illustrated in FIGS. **15**B, **26**, and **27**, rays of light corresponding to the probe beam may be swept. For example, the probe beam (for OCT or SLO) may comprise a beam having a small beam width (e.g., 5 to 10 times or more smaller than the exit pupil of the ocular) that is swept across the focusing lens and/or exit pupil in the ocular of the ophthalmic device. Accordingly, only portions of the rays in the bundle of rays described above will be present at a given time. Nevertheless, in various embodiments, the beam sweeps through the different angles within the cone of angles, α, referred to above. Accordingly, as discussed above, the shape of the mask window can be configured to be sufficiently sloped such that these rays, and in particular, this small beam, is not retro-reflected back into the instrument to introduce noise into the signal as the beam is swept through the range of angles defined by the cone angle, α.

In some embodiments, similar to the mask **100** illustrated in FIG. **1**, the proximal portion **254** of the mask **200** is inflatable or deflatable, and the rear surface **222** is configured to conform to contours of the patient's face and align the one or more substantially optically transparent sections **224** of the distal portion **218** with the patient's eyes when the proximal portion **254** is inflated or deflated. In some embodiments, the mask **200** includes an inflation port (not shown) providing access to inflate or deflate the proximal portion **254**. In some embodiments, the proximal portion **254** has

two cavities **260***a* and **260***b* extending from the rear surface **222** toward the distal portion **218**. The two cavities **260***a* and **260***b* are aligned with the one or more substantially optically transparent sections **224** and defining two openings on the rear surface **222** to be aligned with the patient's eyes. The rear surface **222** is configured to seal against the patient's face so as to inhibit flow of fluid into and out of the two cavities **260***a* and **260***b* through the rear surface **222**. In some embodiments, the mask **200** includes an ocular port (not shown) providing access to at least one of the two cavities for gas or fluid flow into the at least one of the two cavities **260***a* and **260***b*.

Removable Masks

In some scenarios, it may be desirable to provide an ophthalmic device (e.g., an optical coherence tomography device or other ophthalmic diagnostic instrument) with a small interpupillary distance to accommodate many users. In some scenarios, it may be desirable to allow the patient's eyes to be positioned as close to the optical coherence tomography device as possible to increase the field of view for the patient, the device or both the patient and device. In these embodiments, a mask can prolong the life of the optical coherence tomography device by providing an optically transparent barrier between the patient and the device. Without the mask, build-up of contaminants and other environmental factors can damage the optical coherence tomography device or the patient could be injured by moving objects within the OCT device. Additionally, germs may be transferred from one user to another user. Although the embodiments described below are described in relation to an optical coherence tomography device, the hygienic barriers can be used with any ophthalmic system.

The mask can be attached to the optical coherence tomography device before each use and removed after each use such that the mask can be disposed of after a single use or a few uses (e.g., 2, 3, 4, 5, 6, or otherwise). In various implementations, the subject inserts the mask **1032** into the contoured portion **1004** of the OCT device **1000** and then bring his/her head into contact with the mask **1032**. In various implementations, the user could bring his/her head into contact with the mask **1032**, and then insert the mask **1032** into the contoured portion **1004** of the OCT device **1000**. Likewise, the subject may remove his/her head from the mask **1032** and then remove the mask **1032** from the contoured portion **1004** when the examination is complete or remove both his/her head and the mask **1032** from the contoured portion **1004**, and then remove the mask **1032** from the user's head. Disposable masks provide a hygienic barrier between the user and the optical coherence tomography device. Further, unlike reusable masks, disposable masks prevent the build-up of dust or other contaminants on the mask, so the mask can be used with substantial or maximum clarity. The mask **1032**, whether disposable or not, would likely reduce contaminant build up on the OCT device **1000**. The mask also prevents contaminants from entering the optical coherence tomography device and prevents user appendages, such as fingers, from being inserted into the machine where they could be damaged by moving parts.

The hygienic barrier can take the form of a mask as described herein. The hygienic barrier (referred to herein as a "mask" or "goggle") can be attached to and removed from an ophthalmic instrument (e.g., a binocular optical coherence tomography device) such that an incident light beam from the ophthalmic instrument is transmitted to an eye of a user. For a binocular optical coherence tomography device, the hygienic barrier permits incident light beam(s) from the ophthalmic instrument to be transmitted to both eyes of a user.

FIG. **52** schematically illustrates the hygienic barrier **1500**. In general, the hygienic barrier **1500** can include a first optically transmissive section (e.g., optically transparent). The first optically transmissive section can be optically interfaced with the ophthalmic instrument such that, during use, an incident light beam **1520** from the ophthalmic instrument **1510** can be transmitted through the first optically transmissive sections to an eye **1530** of a user. The first optically transmissive section has a light transmission region **1540** through which the incident light beam **1520** is transmitted. Areas of the first optically transmissive section through which the incident light beam is not to be transmitted, if present, do not form a part of the light transmission region **1540**. In some implementations, the first optically transmissive section can form the entirety of the hygienic barrier. In some implementations, one or more edges of the first optically transmissive section may be surrounded by a non-transmissive section. Although FIG. **52** schematically illustrates the mask **1500** having a single curvature, the mask **1500** may have multiple curvatures. For example, as shown in FIG. **48**B, the mask may have a first radius of curvature centered directly behind the nose bridge region and second and third radii of curvature configured to be centered directly behind the respective light transmission regions. The second and third radii of curvature may be the same or different from the first radius of curvature. The second curvature may be the same as the third radius of curvature, or may be different.

In some implementations, the hygienic barrier has a second optically transmissive section. The second optically transmissive section has a light transmission region through which an incident light beam is transmitted to the other eye of the user. Reference to characteristics of the optically transmissive section or first optically transmissive section can also be applied to the second optically transmissive section.

The optical characteristics of the hygienic barrier can help reduce or minimize back-reflections into the detector of the optical coherence tomography device as described above. The optically transmissive section(s) of the hygienic barrier may comprise a material having a shore D hardness of at least 75, at least 80, at least 85, or more. The optically transmissive sections may comprise polycarbonate or PMMA. The desired optical characteristics may also be achieved based on the shape of the hygienic barrier. For example, for some designs, a thickness at any location of the light transmission region can be no greater than about 3.0 mm, no greater than about 2.5 mm, no greater than about 2.0 mm, no greater than about 1.5 mm, no greater than about 1.0 mm, no greater than about 0.75 mm, no greater than about 0.5 mm, no greater than about 0.25 mm, or any ranges between any of these values. The thickness of the entire light transmission region can be substantially uniform (e.g., a thickness at any location of the light transmission region can be within about 0.5% of an average thickness of the light transmission region). A radius of curvature of the light transmission region can be between about 40 mm and about 60 mm, between about 45 mm and about 65 mm, between about between about 50 mm and about 70 mm, or any sub-ranges within these ranges. A length or diameter of the light transmission region can be at least about 15 mm and/or less than or equal to about 40 mm, such as between about 20 mm and about 30 mm, between about 30 mm and about 40 mm, or other ranges between these values.

Since any of the masks or goggles herein can be designed to be removably attached to an ophthalmic instrument, certain masks or goggles may not include features for adhering, attaching, or strongly adhering or attaching to a user's head or face (e.g., straps, armatures, over the ear supports, and/or over the nose supports). For certain masks, the mask is supported by or rests on the ophthalmic instrument, not the user's head or face. Likewise in some cases, if the user's head or face is tilted 15 degrees from a longitudinal axis L of the user (see FIG. **3**) when standing, the mask would fall off the user's head or face. Any force holding the mask to the head or face of the user is not sufficient to overcome the force of gravity. To the extent that the mask has any armatures (e.g., see FIGS. **44**A-**44**D), these armatures may facilitate alignment and not secure the mask to the user's head or face despite gravitational force when the head is in the tilted position. As discussed further below, the mask in FIGS. **44**A-**44**D is still supported by and rests on the ophthalmic instrument.

In some configurations, a lateral side or armature of the mask extends no more than 3.0 inches (or no more than about 2.0 inches or no more than 2.0 inches, or no more than 1.5 inches, or no more than 1.0 inches, or any ranges between any of these values) from the anterior surface of the mask, such that the posterior end of the mask is anterior of the user's ear. Since the mask is not supported by the user's face, in some implementations, there may be no cushions in the forehead and/or nose regions of the mask.

Described below are different features for attaching the masks to the optical coherence tomography device in a stable manner, but so the mask can be easily removed. Features are also provided to prevent or reduce movement of the user's head to improve visualization of the internal displays and improve OCT measurements. Additional components may be present, such as a disposable nose and/or forehead shield.

FIG. **30**A illustrates a binocular optical coherence tomography device **1000** (also referred to herein as OCT device or OCT machine) having a contoured receptacle **1004** configured to adapt the OCT device **1000** to receive the mask **1032**. The contoured receptacle **1004** can be integrally formed with or permanently secured to the OCT device **1000**. However, as described further below, the contoured receptacle **1004** can be a separate component removably secured to the OCT device **1000**. In either case, the contoured portion **1004** can be constructed from a metal, plastic, or other material.

The contoured receptacle **1004** can provide a non-planar contoured receptacle interface **1008** (e.g., generally concave) to receive the mask **1032**. As shown in FIG. **30**A, the contoured receptacle **1004** can include spaced apart apertures **1016** that provide a conduit between the eyes of the user and optics of the OCT device **1000**. The apertures **1016** can be spaced apart by a bridge **1020** to receive a bridge **1044** of the mask **1032** (see FIG. **31**). As described in further detail below, the contoured receptacle **1004** can include attachment features such as attachment portions **1024** on lateral sides of the contoured receptacle **1004** for removably securing and stabilizing the mask **1032**. Attachment features can be positioned at any number of locations, such as around a periphery of the contoured receptacle **1004** to secure the mask **1032**. For example, the contoured receptacle **1004** can include a number of retention members **1022** around the periphery of the contoured receptacle **1004** to constrain mask **1032** movement in one or more directions. The retention members **1022** can be surface features (e.g., projections, ridges, pins, indentation, opening, etc.) that restrain movement of the mask **1032** or engage corresponding features of the mask **1032** (e.g., a groove, ridge, indentation, or opening and a corresponding projection, ridge, extension, etc.). As shown in FIG. **30**A, the contoured receptacle **1004** can include a retention member **1022** along an upper region of the bridge **1020** to restrain upward movement of the mask **1032**. The contoured receptacle **1004** may include additional retention members **1022** along an upper or lower edge of the contoured receptacle. The attachment between the mask **1032** and the contoured receptacle **1004** constrains the mask **1032** from movement in at least one, possibly, two, three, or more degrees of freedom. Overall, the mask may be constrained in six degrees of freedom (x, y, z, and three degrees of rotation) yet allows easy attachment and removal of the mask **1032**. The mask being so constrained, the mask constrains the subject's head.

Upward of the contoured receptacle **1004**, the OCT device **1000** can include a forehead region **1002** against which the user's head rests. Downward of the contoured receptacle **1004**, the OCT device **1000** can include a nose recess **1012** for receiving the user's nose. A microphone can be positioned in or around the nose recess **1012** for voice recognition purposes (e.g., for activating the OCT device, commanding the OCT device, providing input or feedback to OCT instruments, etc.). Although not shown, when the mask **1032** is engaged with the contoured receptacle **1004**, the mask **1032** may extend upward or downward of the contoured receptacle **1004** to provide a larger hygienic surface. A forehead shield and/or a nose shield of the mask **1032** may be rigid or flexible to adjust to the contours of the user's face. In other embodiments, the forehead shield **1001** and/or the nose shield **1003** may be separate disposable components that may be attached to the OCT device **1000** before or after the attachment of the mask **1032** (see FIG. **30**C). For example, the forehead shield **1001** and the nose shield **1003** can be thin pieces (e.g., made of plastic) removably adhered to the OCT device **1000**. A stack of such forehead shields **1001** and/or nose shields **1003** may be adhered to the OCT device **1000**. A single forehead shield **1001** and/or a single nose shield **1003** may be removed after a subject completes an examination. The forehead shield **1001** and the nose shield **1003** can be applied prior to the attaching the mask **1032**. However, in other implementations, the forehead shield **1001** and the nose shield **1003** may be applied after attaching the mask **1032**.

In some scenarios, it may be desirable for the OCT device **1000** to include an interlock switch **1076** (see FIG. **30**A) or switches or sensors, such as electrical contact, optical, resistance-based switches, or other sensor, to indicate engagement of the mask **1032** with the OCT device **1000**. The interlock switch **1076** can be positioned along the interface **1008** or on the lateral surfaces **1024** used to secure the mask **1032** to the contoured receptacle **1004**. These switches **1076** can be configured to stop movement of internal components or operation of the OCT device **1000** if the mask **1032** is not inserted during device or exam startup or if the mask is removed during operation of the optical coherence tomography device.

As shown in FIG. **30**A, the OCT device **1000** can include shutter(s) **1028**, for example, distal of the contoured receptacle **1004** or within the apertures **1016** of the contoured receptacle **1004**. FIG. **30**A illustrates the shutter(s) **1028** in a closed position (see FIG. **30**A) when the mask **1032** is detached or incorrectly attached to the contoured receptacle **1004**. As shown in FIG. **30**B, the shutters **1028** can be

configured to transition to an open position (see FIG. **30**A) when the mask **1032** is correctly attached to the contoured receptacle **1004**.

As shown in FIG. **31**, the mask **1032** can include optically transparent sections or portions **1040** (e.g., optically transparent to light wavelengths between 400 nm and 1550 nm or to visible light waves or one or more portions of these wavelength regions). In certain embodiments, the instrument uses wavelength at or around 450, 520, 635, 780, 830 and 1000-1120 nm. Therefore, the mask or goggles and in particular one or more optically transparent section may, in some implementations, transmit more than an octave of light wavelengths. In some embodiments, the optically transparent portions **1040** are optically transparent to light wavelengths between 450-650 nm, 750-850 nm, 980-1120 nm, or any combination thereof. The optically transparent sections **1040** may be transparent to one or more portions of these ranges or of the visible and/or near IR spectrums in some embodiments.

In some embodiments, the thickness of the mask **1040** is the same from the center to the edge to reduce optical distortion. Such constant thickness embodiments may, for example, have inner and outer or front and rear surfaces of the distal sheet member that are spherical curvatures having the same center of curvature. This center of curvature may, in different examples, be disposed in the central meridian through the nose and likewise through the center of eyewear. In certain cases, where the mask includes separate left and right substantially optically transparent sections for the left and right eye's respectively, each transparent section may have a corresponding center of curvature that coincides with the center of curvature for both the front and rear surface of the substantially optically transparent section. In some cases, the centers of curvature to coincide with the centers of the eye or pupil of an average person. For instance, the centers of curvature for the left and right eyes might be separated by 60 mm or 65 mm or a distance therebetween. In certain implementations, the centers of curvature are separated by 34 mm so the centers of curvature are neither on the meridian nor on the pupillary axis. A constant thickness can reduce aberration (e.g. distortion). In some embodiments, the thickness of the mask **100** is the same (e.g., from center toward the edge or for the left substantially optically transparent section or for the right substantially optically transparent section) over an area of about 2 cm^2, 3 cm^2, 4 cm^2, 5 cm^2, 6 cm^2, 7 cm^2, 8 cm^2, or ranges between any of these values. The area may be larger or smaller as well in different implementations. This thickness may be, for example, about 0.5 mm thick or other values. Other thicknesses could include 0.1 mm, 1.0 mm, 1.5 mm, 2.0 mm, or 2.5 mm. In various embodiments, the thickness might be sufficient to be impact resistant. In various embodiments, therefore, the impact resistance for the mask complies with the ANSI standard ANSI Z87. In one example, the outer radius is 54 mm, the inner radius is 53.5, and the thickness is 0.5 mm. The center of curvature is the same and the surfaces are spherical. In another example, the window may be thinner in the middle and thicker at the edge. The inner (back) radius can be smaller than the outer (front) radius, but the center of curvature for the inner radius is shifted forward to create a thin portion at the center (e.g., 12 o'clock position in the cross-section in the nasal-temporal meridian) and relatively thicker portions toward the edges.

The optically transmissive portions or sections **1040** can be separated by a mask bridge **1044** that is received by the bridge **1020** of the contoured receptacle **1004**. When the mask **1032** is correctly attached to the contoured receptacle **1004**, the optically transmissive portions **1040** can align with the apertures **1016** of the contoured receptacle **1004**. In this manner, light from a light source in the OCT machine can be directed onto the subject's eyes and light reflected or scattered from the subject's eye can be directed to optics in the OCT device **1000**. The mask **1032** can include a proximal surface **1048** and a distal surface **1052** (see FIG. **32**A). The proximal surface **1048** can provide an interface between the mask **1032** and the user (e.g., user's head, face, etc.), while the distal surface **1052** can provide an interface between the mask **1032** and the contoured receptacle **1004**.

As shown in FIGS. **32**A-**32**C, the mask **1032** can include armatures **1034** on each lateral side of the mask **1032**. A distal portion of the armature **1034** can include an attachment portion **1036** configured to interface with the attachment portions **1024** of the contoured receptacle **1004**. Appendages **1056** may extend proximally from the attachment portions **1036** to provide a lateral interface between the mask **1032** and the user (e.g., sides of user's face and/or head) and limit or prevent lateral movement of the user's head when the mask is secured to the OCT device **1000**. The appendages **1056** may be cushioned to provide comfort and/or resilient to conform to a width of the user's head. In one example, the appendages **1056** may be curved (e.g., curved radially inward of the attachment portions **1036**).

FIGS. **32**A-**32**C illustrate the steps of attaching the mask **1032** to the contoured receptacle **1004**. In FIG. **32**A, the armatures **1034** are positioned in an initial configuration. The armatures **1034** can flex so the attachment portions **1036** of the contoured receptacle **1004** can be inserted into attachment portions **1024** of the contoured receptacle **1004** (see FIG. **32**B). For example, the armatures **1034** can be springs biased to the initial configuration. The armatures **1034** can be, for example, plastic springs (e.g., including PMMA) or metal springs. The attachment portion **1024** of the contoured receptacle **1004** can include a recess **1026** configured to receive a protrusion **1038** of the attachment portion **1036** of the mask **1032** (or other combination of features to form a snap-fit or other interlocking joint). Although, in other configurations, the attachment portion **1024** of the contoured receptacle **1004** can include a protrusion to be received by a recess of the attachment portion **1036** of the mask **1032**. In some embodiments, the attachment portions **1036** can return to the initial configuration when the attachment portions **1036** of the mask **1032** engages the attachment portions **1024** of the contoured receptacle **1004** (see FIG. **32**C).

In other configurations, the attachment portions **1024** of the contoured receptacle **1004** can flex instead of or in addition to flexure of the flexible armatures **1034** described above. For example, as shown in FIGS. **33**A-**33**C, the attachment portions **1024** can flex outward to accommodate the attachment portions **1036** of the mask **1032**. Similar to the armatures **1034**, the attachment portions **1024** can be springs biased to an initial configuration. The attachment portions **1024** can be, for example, plastic springs (e.g., including PMMA) or metal springs.

Other attachment features than those described above are imaginable. For example, the attachment portions **1024** of the contoured receptacle **1004** and the attachment portions **1036** of the mask **1032** can form a ball detent connection. As shown in FIGS. **34**A-**34**C, the attachment portion **1024** of the contoured receptacle **1004** can include a number of ball features **1060** (e.g., one, two, or more), while the attachment portion **1036** of the mask **1032** can include a number of corresponding openings **1064**. Although, in other configurations, the attachment portion **1036** of the mask **1032** can include the ball features and the attachment portion **1024** of

the contoured receptacle **1036** can include the openings. Other arrangements are possible. Similar to the embodiments described above, the armatures **1034** and/or the attachment portions **1024** of the contoured receptacle **1004** may flex.

Notably, in various embodiments such as those described above and elsewhere herein while the mask is worn, the armatures **1034** apply inward pressure keeping the subject's movement at least somewhat constrained when the mask **1032** is attached to the OCT device **1000**. Additionally, while the mask **1032** is worn and the mask **1032** is attached to the contoured receptacle **1004**, the outward pressure applied by the subject's head on the armatures **1034** promotes secure engagement with the OCT device **1000** by pressuring the armatures **1034** against the contoured receptacle **1004** (e.g., attachment portions **1024**).

In yet another configuration, the mask **1032** can be removably connected to the contoured receptacle **1004** using fasteners (e.g., screws, posts, adhesives, or otherwise). As shown in FIG. **35**A, the mask **1032** can include a lateral extension **1068** extending from each armature **1034**. The fastener **1072** can join the lateral extension **1068** to the contoured portion **1004**.

As shown in FIGS. **36**A and **36**B, the appendages **1056** can flex to accommodate the user's head after the attachment portion **1036** of the mask **1032** engages the attachment portion **1024** of the contoured portion **1004**. FIG. **36**A illustrates the appendages **1056** in an initial configuration. As the user's head moves toward the mask **1034**, the appendages **1056** can flex outward to accommodate the user's head (see FIG. **36**B). A distal portion of the appendages **1056** or a junction between the appendages **1056** and the attachment portion **1036** of the mask **1032** can flex against the attachment portions **1024** of the contoured receptacle **1004**. When the user is properly wearing the mask **1032**, an inner surface **1058** of the appendage **1056** can contact the user's head to constrain lateral movement of the user's head. The inner surface **1058** may be cushioned (e.g., with foam, gel, or other conformable material) to increase comfort. As described above, the armatures **1034** can be springs biased to the initial configuration, such that when the user's head is removed, the armatures **1034** can return to the initial configuration. In certain embodiments, the mask armatures **1034** and appendages **1056** bend in a direction to secure the mask to the OCT system that is configured to be different or opposite in direction to the bending direction of the armatures and appendages used to constrain the user's head.

In various designs, the area between the apertures acts as a surface on which the nasal bridge and forehead rest and thus constrains the head movement in that direction as well.

A shape of the mask **1032** can be designed to leave gaps **1088** between the mask **1032** and the user's head, for example, face, (see, e.g., FIGS. **36**B, **37** and **38**). The gaps **1088** allow room for air to flow between the user's head and the mask **1032** to prevent fogging. At least some of the gaps **1088** may be oriented radially around the center of the user's eyes.

As shown in FIG. **37**, the appendages can include a flexible component **1080** and a cushion **1084** attached to a proximal end of the flexible component **1080**. Similar to the appendages **1056**, the flexible component **1080** can flex to accommodate the user's head. The cushion **1084** provides added comfort to the user. Additionally or alternatively, as shown in FIG. **37**, the bridge **1044** of the mask **1032** can include a cushion **1046** for user comfort and increase the gap **1088** between the user's head and the mask **1032**. A plurality of contact points between the mask **1032** and the face, for example, created by the cushions, can establish the gaps.

In other configurations, the attachment portions **1024** can extend proximally of a proximal-most end of the mask **1032**, such that the attachment portions **1024** and can restrain lateral movement of the user's head (see FIG. **38**A). After the mask **1032** engages the contoured receptacle **1004**, the proximal portions of the attachment portions **1024** may flex to accommodate the user's head. As described above, the attachment portions **1024** can be springs biased to the initial configuration, such that when the user's head is removed, the attachment portions **1024** can return to the initial configuration. The proximal portions of the attachment portions **1024** may include cushions **1092** to increase comfort. Since the cushions **1092** are attached to a semi-permanent part of the device **1024**, these cushions may be removable and disposable for hygiene reasons. The mask **1032** can be secured to the receptacle **1004** by a variety of approaches such as described herein. Similar to earlier embodiments, the shape of the mask **1032** and the attachment portions **1024** can facilitate the creation of the gaps **1088** to decrease fogging. As shown in FIGS. **37** and **38**, the nose cushion as part of the mask, constrains the subject's head in one direction.

As discussed above, the contoured portion **1004** can be separately attached to the OCT device **1000**. FIGS. **39**A-**42**D illustrate a contoured portion **1104** that can be included with a mask **1132**. As shown in FIGS. **39**A-**39**D, the mask **1132** can comprise an optical transparent window (e.g., transparent to light wavelengths between 400 nm and 1550 nm or between about 450 nm and 1150 nm). In some configurations, the entire mask **1132** may be the optically transparent window. As one example, at least the window or optically transparent section can be constructed from PMMA although other optically transparent materials may be used. The window or optically transparent section can be configured with a compound curvature (in both X and Y axes) to reduce back-reflections into the optical coherence tomography device. This curvature in different meridians or directions may be the same as in a spherical shape or different as in ellipsoid or paraboloid shapes. In some embodiments, such as when the surface is spherically shaped, this curvature is defined by a radii of curvature such as for example 25 mm, 40 mm, 50 mm, 51 mm, 54 mm, 55 mm or 60 mm or in one or more ranges between any two of these radii. Alternatively, the window or optically transparent section can include any of the curvature features described in the other mask embodiments.

The thickness of the window or optically transparent section can be configured to be equal across its length or vary with length, such as by thinning in the area in front of each of the user's eyes. See, e.g., FIGS. **40**A-**40**D in which the region or section **1196** configured to align with each of the user's eyes has a reduced thickness to reduce aberration, such as astigmatism. The regions **1196** can have constant reduced thickness. The thickness in these optically transparent regions or sections **1196** may be between 0.1 mm-0.5 mm, 0.1 mm-1.0 mm 0.1 mm-3.0 mm or any other range formed by any of these values. For example, the thickness may be 0.5 mm. This region **1196** may be at least 2 cm^2, 3 cm^2, 4 cm^2, 5 cm^2, 6 cm^2, 7 cm^2, 8 cm^2, or ranges between any of these values.

In various implementations, the optics of the OCT system, with the addition of the region(s) or section (s) **1196**, are diffraction limited and have a total RMS wavefront error of less than 0.07 waves. In other implementations, the combined RMS wavefront error of some of the optics of the OCT

system and the window region(s) or optically transparent sections(s) **1196** is less than 0.07 waves but the combined wavefront error of other optics in the OCT system and the window region(s)/optically transparent section(s) **1196** is greater than 0.07 waves but less than 0.25 waves. In some implementations, the combined wavefront error of the OCT system and the window region(s) is less for certain wavelengths or ranges of wavelengths of light, such as 400 nm-700 nm and greater for other wavelengths or ranges of wavelengths of light such as 700 nm-1500 nm. Other configurations that reduce or minimize the combined RMS wavefront error of the optics of the OCT system and the window region(s)/section (s) **1196** are possible. Reduced thickness of the regions or sections **1196** through which the beam of light from the OCT travels to and from the eye may reduce the contribution of wavefront error. This reduced wavefront error can be useful in enabling the subject to read an eye chart and may also have the added benefit of not adversely affecting the OCT signal. With reduced wavefront error, the OCT optics (and the attached goggles, which effectively become part of the optical system) allow a user to see the 20/20 E. In this case, the resolution is 1 arc minute on the retina. This low wavefront error may potentially be beneficial for the OCT imaging as well.

The quality of the optical surface, which may be an injection molded component, also is such that contribution to wavefront error is reduced. In some implementations, the regions or sections **1196** have reduced thickness (e.g., from about 0.25 mm to about 0.5 mm) while the thickness increases toward the peripheral regions **1198** or regions peripheral to the sections **1196** and/or the edges of the mask in one or more directions, thereby providing mechanical strength. In some embodiments, the thickness may increase for example to 1.0 mm or more in the peripheral regions **1198**. These peripheral regions **1198** need not be transparent. Instead these thicker peripheral regions **1198** may be translucent or opaque or combinations thereof. The peripheral region **1198** may also be of less optical quality (e.g., have higher RMS error) than the optically transparent regions **1196**.

A single piece comprising the thin regions **1196** and the thicker peripheral region **1198** is one option. These thicker peripheral regions **1198** may potentially be translucent or opaque. Other designs can include multiple pieces such as one or more thin transparent pieces for the regions/sections **1196** and one or more thicker, possibly translucent or opaque, peripheral regions on opposite sides of the window region(s)/section (s). The materials used for the multiple pieces may not be the same. For example, the thin region/section **1196** could be made from PMMA or polycarbonate while the peripheral regions **1198** could be made from ABS or polyethylene. Other materials are possible. In some implementations, a single molded piece includes the thin regions/sections **1196** and a step or sharp increase in thickness to the thicker peripheral region **1198**. Injection molding can be used to form this single piece or separate thin regions/sections **1196** for multi-piece designs which can be assembled into an aggregate structure after molding.

As described above, the mask material is preferentially transparent in a window or window region/section in front of the user's eyes and is capable of transmitting a wide range of wavelengths of light, such as between 400 nm and 1550 nm or at least between 450 nm and 1150 nm. For example, the window or window region may be optically transparent over the ranges 450-650 nm, 750-850, 980-1120, or combinations thereof. Likewise, in various embodiments the window region or section can be optically transparent over a portion of the visible spectrum and/or a portion of the near-infrared spectrum. In various embodiments, only the thin regions **1196** transmit light with high efficiency (e.g. greater than 99.9%, 99.5%, 99%, 95%, 90%, 80% or 50%) while other areas of the mask may be opaque or translucent and/or transmit little or no light (e.g., less than 30%, 20%, 10%, 5%, 1%, or 0% of visible light or any range defined by these percentages). The overall base curve **1194** of the mask **1132**, the curve formed by the left and right optically transparent windows or sections, and/or the interface between the mask **1132** and the user can be configured to closely match the curvature of the average head to reduce or minimize stand-off distances between the machine optics and the eye. For example, the base curve may be 8, 10, or 12 or possible 4, 6, or 8, or any range between any of these values.

The mask **1132** (e.g., FIGS. **41**A-**42**D) can be molded with a contoured receptacle **1104** or parts thereof, such as the optically transparent section and peripheral regions can be molded separately and attached to the contoured receptacle **1104** (see FIGS. **41**A-**41**D). The contoured receptacle **1104** can be molded from a plastic material to make it cost efficient and disposable. Providing a contoured receptacle **1104** separate from the OCT device **1000** may be useful if the user interface of the OCT device **1000** has a planar surface. The contoured receptacle **1104** can provide a non-planar, contoured surface for receiving at least portions of the mask **1132**, such as transparent sections and/or peripheral sections, and the user's head. The contoured receptacle **1104** can be secured to the OCT device **1000** using fasteners (e.g., locking pins, screws, adhesives, or otherwise). For example, the contoured receptacle **1104** can include openings **1105** to receive the fasteners. The openings **1105** can be positioned at a periphery of the contoured receptacle (e.g., at lateral regions of the contoured receptacle **1104**).

The contoured receptacle **1104** can include one opening large enough to receive both of the user's eyes or at least both thinned, optically transparent sections or regions **1196**. Alternatively, the contoured receptacle **1104** can include spaced apart apertures that align with the user's eyes when the contoured receptacle **1104** is attached to the OCT device **1000** or align with the optically transparent sections or regions **1196**.

As shown in FIGS. **42**A-**42**D, a comfortable, deformable portion **1106** (e.g., formed from silicone rubber, foam, gel, paper, or otherwise) can be interposed between the transparent sections (and possibly peripheral regions thereto) of the mask and the user's head. In various cases, this deformable portion **1106** can conform to the user's head for comfort. The deformable portion **1106** can be more flexible than the optically transparent section **1196** and the peripheral regions **1198** the mask **1132** and can constrain movement of the user's head when engaged in the mask **1132**. In some configurations, as shown in FIGS. **42**B-**42**D, the deformable portion **1106** can include an integrated nose shield **1107** to provide a hygienic barrier between the user's nose and the OCT device. In other configurations, the nose shield **1107** can be separately formed from the deformable portion **1106**. The nose shield **1107** can be formed from silicone rubber, polyethylene, foam, gel, paper, plastic, or otherwise. The deformable portion **1106** and/or the nose shield **1107** may be inflatable.

As described above, it may be desirable to leave gaps between the mask and the user's head to prevent fogging. The mask **1132** and/or deformable portion **1106** may include recesses or other openings to prevent fogging. Alternatively, the mask **1132** may be coated with an anti-fog composition.

Other configurations of masks **1132**, contoured receptacles **1104**, and deformable portions **1106** are imaginable. For example, as shown in FIGS. **46**A and **46**B, the optically transparent sections **1196** and the peripheral regions **1198** (e.g., of FIG. **39**A-**39**D or **40**A-**40**D) can be secured to a deformable portion **1106**, but not a contoured portion **1104**. In some instances, the mask **1132** may be adapted for a contoured portion permanently fixed to the OCT device. FIGS. **47**A and **47**B illustrate another variation in which the mask assembly includes the optically transparent sections **1196** and the peripheral regions **1198**, the contoured receptacle **1104**, and the deformable portion **1106**. However, unlike the contoured receptacle **1104** shown in FIGS. **41**A-**41**D, an outer periphery of the contoured portion **1104** aligns substantially or entirely with an outer periphery of the peripheral regions **1198** surrounding the optically transparent sections **1196**.

FIGS. **43**A-**43**C illustrate a method of attaching a mask assembly **1200** including the optically transparent sections **1196** and the peripheral regions **1198**, frame **1104**, deformable portion **1106**, and/or nose shield **1107**. FIG. **43**A illustrates an OCT device **1100** in an inactive state. The OCT device **1100** has a shield **1101** over the patient eyepiece portal. The shield **1101** can be held in place by structures such as spring-loaded solenoid pins. The spring-loaded pins may comprise solenoids that when activated move the pins against the spring force of the spring. The movement of some solenoids against the spring force of the spring can cause the solenoids to extend their pins. Other solenoids can be configured to retract their pins against the spring force when powered. In one embodiment of a shield **1101**, holes are configured in the shield **1101** to receive spring-loaded pins that extend from a solenoid when the solenoid is unpowered. In another embodiment of a shield **1101**, holes are configured in the shield **1101** to receive spring-loaded pins that extend from a solenoid when the solenoid is powered. As shown in FIG. **32**B, the OCT device **1100** can include a recess **1103** that slidably receives an edge the mask assembly **1200** (e.g., a lateral edge of the contoured receptacle **1104**). Although not shown, the recess **1103** can include a microswitch that causes the solenoids to receive power and retract the pins holding the shield **1101**. This allows the user to move the shield **1101** (e.g. depress a spring-loaded shield **1101**), so the mask assembly **1200** can be moved into place (see FIG. **43**C). When the mask assembly **1200** is in place, a second microswitch can be triggered to cut power to the solenoids and allow the spring-loaded pins to engage the mask assembly **1200** (e.g., through the openings **1105** in the contoured receptacle **1104**). If the second microswitch is triggered without triggering the first microswitch, the machine will know that a user has lifted the shield **1101** by hand and will not begin the exam.

FIG. **44** illustrates a method of using an interlock mechanism to prevent removal of the mask **1032** during operation of the OCT device **1000**. When the mask **1032** is inserted into the contoured receptacle **1004**, the mask **1032** can push back spring-loaded solenoid pins in the OCT device **1000** to trigger a first microswitch(es). When the mask **1032** is fully inserted, a second microswitch(es) can be depressed to indicate full insertion of a mask **1032**. When the mask **1032** is fully inserted, the OCT device **1000** can power the spring-loaded solenoid pins to extend into receptacles in the mask **1032**. The presence of these pins in the mask receptacles will prevent removal of the mask **1032** as long as the solenoids remain in a powered state. When unpowered, the spring-loaded solenoid pins can retract to allow removal of the mask **1032** from the contoured receptacle **1032**. After the mask **1032** has been removed, the OCT device **1000** can prompt the user to insert a new mask **1032**. If an exam is initiated when a microswitch(es) is depressed (i.e. indicating the presence of a mask **1032** in the contoured receptacle **1004**), the OCT device **1000** can request that the user remove the mask from the contoured receptacle **1004** (for example if the previous subject has left their used mask in the OCT device). In other configurations, only one of the microswitches may be present or additional microswitches may be present.

As shown in FIGS. **44**A-**44**D, schematically illustrate an embodiment of the interlock system. In FIG. **44**A, the mask **1132** is inserted into the contoured receptacle **1104** while the OCT device is powered on. As the mask **1132** moves toward the contoured receptacle **1104**, the mask **1132** pushes the spring-loaded solenoid pins **1182** to trigger the switches **1186** (see FIG. **44**B). In one embodiment, after the mask **1132** is advanced into engagement with the contour portion **1104**, the mask **1132** can trigger the microswitches **1190** and release microswitches **1186** if the mask **1132** is correctly positioned (see FIG. **44**C). The OCT device can be configured to only release the shield or shutter protecting the OCT device and begin examination when the mask **1132** triggers the microswitches **1190** and releases microswitches **1187**. In some configurations, the solenoid pins **1182** can secure the mask **1132** to the OCT device so that it cannot be removed during operation. After examination is complete, the OCT device may instruct the user to remove the mask **1132**. In some configurations, if the solenoid pins **1182** are holding the mask **1132** in place, the solenoid pins **1182** can be deactivated to permit the mask **1132** to be removed. After the OCT device senses that the mask **1132** has been removed (e.g., from the release of the switches **1190** and/or transient depression of microswitches **1186**), the power to the solenoid pins **1182** can be reactivated and the user can be prompted to insert a mask **1132**. There may be a timer to create a delay before prompting the user to insert the mask **1132**. In other configurations, only one of the microswitches may be present or additional microswitches may be present. In some configurations, the switches are configured to be normally open. In other configurations, the switches are configured to be normally closed. In addition, in some embodiments, the solenoids are configured to extend their pins when unpowered.

FIG. **45** illustrates another embodiment of a disposable mask **1032** and a contoured receptacle **1004** permanently attached to the OCT device (not shown). Similar to FIGS. **34**A-**34**C, the mask **1032** can engage the contoured receptacle **1004** using a ball detent feature. The armature **1034** can include a cutout **1045** at a junction between the attachment portion **1036** and the appendage **1056** to reduce a thickness at the junction. The size of the cutout **1045** can be used to modify the spring constant of the armatures **1034**. The spring constant gets weaker as the material gets thinner, while the spring constant gets stronger as the material gets thicker. This may be useful to create different masks **1034** for various head sizes. Users with large heads may require armatures **1034** with weaker spring constants than users with smaller heads. In other configurations, the spring constant of the armatures **1034** can be varied using cross-beam supports or different material.

Further, the nose bridge **1044** of the mask **1032** can include a compressible cushion **1046** for user comfort and/or to provide a gap between the mask **1032** and the user to prevent fogging. In some embodiments, the mask is reusable. In other embodiments, the mask is single use or

disposable and intended to be used by one patient, subject, or user, and subsequently disposed of and replaced with another mask for use for another person. In some embodiments, the mask is configured for limited re-use (e.g., 2, 3, 4, times etc.) for example by one patient, user, or subject and subsequently disposed of. More than such limited use may result in noticeable wear or indications of usage.

In various embodiments, the optical transparent sections **124** of the mask are configured to increase or maximize transmission of light, such as from an OCT device, and the proximal portions **154** and concaved rear surface **122** is configured to reduce or minimize transmission of light, such as ambient light or light not emanating from an OCT machine and may be opaque and include opaque sides. For example, the proximal portions **154** may have sides that are substantially non-transmissive to visible wavelengths. These sides may for example block 80-90%, 90-95%, 95-99%, and/or 99-100% of ambient visible light. Reduction of ambient light may for example assist in keeping the patient's pupils dilated. Conversely, the optically transparent sections may have a transmittance of 70-80%, 80-90%, 90-95%, 95-99%, and/or 99-99.5%, or 99.5%-100% or any combination of these ranges in the wavelength range at which the ophthalmic device operates such as at 450 nm, 515 nm, 532 nm, 630 nm, 840 nm, 930 nm, 1060 nm, 1310 nm, or any combination thereof or across the visible and/or near IR wavelength range or at least 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, or 90% of that range.

Methods and configurations for reducing retro-reflection back into the instrument can be used including any combination of the foregoing such as a combination of tilt and anti-reflective coatings.

One use for the AR coating on these goggles could be to increase transmission of emitted light into the eye. Optical instruments that sense back-reflected light (e.g. imaging instruments) often benefit from or require very sensitive instrumentation (e.g. avalanche photodiodes, interferometers, etc.) if the level of back-reflected light is low. Additionally, since the tissues in the eye are not very reflective, the low signal level of light back-reflected from the eye tissue to be imaged or evaluated by the ophthalmic imaging or diagnostic systems may be lost in noise if the ghost back-reflections are sufficiently high. As discussed above, reducing the optical interfaces that will be perpendicular to the incident beam at any point may advantageously reduce back-reflection that introduced noise. Various embodiments, therefore, employ tilting or curving the surface of the window. Additionally, signal can potentially be strengthened by increasing transmission of light (and consequently by reducing reflections) at some, many, most, or every surface to increase or maximize power going both to and coming from the eye. This goal can be accomplished, for example, with AR coatings. Advantageously, in various embodiments, this increased transmission is accompanied by reduced reflections, which improve the signal-to-noise ratio (SNR) and contrast in the images, or data produced and reduce ghost artifacts that can appear as real objects, for example, in an OCT or other image. Other instruments may benefit for similar or different reasons. Although various embodiments of the mask have been discussed above in connection with an optical coherence tomography device the mask may be used with other diagnostic instruments or devices and in particular other ophthalmic devices such as a scanning laser ophthalmoscope (SLO).

Anti-Fogging

Any of the hygienic barriers, masks, or goggles described above can include one or more features to reduce or prevent fogging. For example, as described above, the mask can have an anti-fog coating. As another example, the mask can be shaped to leave a gap between the mask and the user's head for ventilation. As described below, in some designs, it may be desirable to provide a positive air flow source to reduce or prevent fogging. Depending on the design, air can be vented into or out of the OCT or other ophthalmic instrument (including ophthalmic diagnostic instruments). The masks **1300** described below may form the entirety of the mask or only a portion of the mask, e.g., the masks **1300** may have any of the features described herein for attaching the mask to the ophthalmic instrument and/or features to facilitate alignment with the user's face or head.

FIG. **48**A, for example, illustrates a mask **1300** that can include any of the features (e.g., contours, dimensions, material, etc.) of the masks or goggles described above or elsewhere herein. The mask **1300** can include at least one aperture **1310** (e.g., one, two, three, four, or more) to facilitate air flow through the mask **1300**. The aperture(s) **1310** can be positioned anywhere on the mask **1300** that avoids obstructing the eye exam (e.g., outside the light transmission region of the optically transmissive section(s)), for example, at a periphery of the mask **1300**. In some implementations, at least one aperture **1310** can be positioned near each lateral edge **1320** of the mask **1310** (e.g., closer to a lateral edge **1320** of the mask **1300** than a longitudinal axis L of the mask **1300**). In some implementations, at least one aperture **1310** can be positioned closer to an edge of the anterior portion of the mask than a longitudinal axis L of the mask, such as shown in FIG. **48**A, (e.g., within about 2.0 inches from an edge of the anterior portion, or within about 1.0 inch from the edge of the anterior portion). In alternative or in addition to the aperture (s) **1310** at the lateral periphery, one or more apertures **1310** can be positioned near an upper edge **1304** of the mask **1300** (e.g., closer to an upper edge **1304** of the mask **1300** than a transverse axis (perpendicular to the longitudinal axis L) of the mask **1300**) (see FIG. **48**F), positioned near a lower edge **1308** of the mask **1300** (e.g., closer to an lower edge **1308** of the mask **1300** than a transverse axis (perpendicular to the longitudinal axis L) of the mask **1300**) (see FIG. **48**E). In these configurations, the one or more apertures may be within about 1.0 inches or within about 0.5 inches from an upper and/or lower edge of the mask **1300**. In some configurations, one or more apertures **1310** may be positioned at a central or nasal bridge portion **1312** of the mask **1300** (see FIG. **48**D). In some configurations, apertures **1310** can be positioned in different locations across the mask (see FIG. **48**G), including at the transition **1325** between the anterior portion **1305** of the mask and the armatures **1315**. The mask **1300** may also include apertures **1310** in the nose region **1312** of the mask. If the mask includes proximally extending armatures **1315**, the mask may also include apertures **1310** to facilitate the transmission of audio to the user's ears. For example, the OCT or ophthalmic instrument may include speakers for the ears and the holes may transmit the audio from the speakers to the ears. The armatures in such instance provide a hygienic barrier with respect to the speakers. In some configurations, the mask **1310** may include a forehead support and/or a portion for receiving or covering the nose (not shown). One or more apertures **1310** may be positioned in the forehead support and/or nasal region of that mask. In some configurations, the mask **1310** may include a cushion (e.g., along a forehead portion, a nasal bridge portion, a lateral temple portion, and/or otherwise). In those configurations, one or more apertures **1310** may be positioned near or directly under the cushion (e.g., closer to the cushion than

a longitudinal or transverse axis of the mask). In embodiments that include a proximally extending portion (e.g., FIGS. **21**A to **21**D), the apertures **1310** can be located anywhere on the proximally extending portion (e.g., anywhere on proximal portion **254**, which may be integral or separate from distal portion **218**), for example on the lateral sides of the mask.

The number and size of the apertures **1310** can be selected to reduce or prevent fogging across the entire anterior surface of the mask **1300**. For example, in the illustrated embodiment, the mask **1300** can include two apertures **1310** (or more) positioned near each lateral edge **1320**. The apertures **1310** on each side of the mask **1310** can be positioned along an axis that is substantially parallel to a longitudinal axis L of the mask **1300** (e.g., within about ten degrees of parallel with the longitudinal axis L). In other configurations, the apertures **1310** can be positioned along an axis that is substantially perpendicular to a longitudinal axis L of the mask **1300** (e.g., within about ten degrees of perpendicular with the longitudinal axis L) or can be positioned in any other configuration.

As shown in FIG. **48**A, each aperture **1310** can be circular. In other configurations, the perimeter of each aperture **1310** can take on any other shape, e.g., rounded, elliptical, triangular, rectangular, etc. The apertures **1310** can have the same shape and/or size or different shapes and/or sizes. The apertures **1310** can be sized to permit an air flow between about 0.001 and about 0.5 L/min, such as between about 0.001 and about 0.1 L/min, or between about 0.05 and about 1.5 L/min, or otherwise. The cumulative open area of all of the apertures **1310** can be between about 0.05 sq. inches and about 2.0 sq. inches. For example, the cumulative open area of all of the apertures **1310** can be between about 0.05 sq. inches and about 0.5 sq. inches, between about 0.25 sq. inches and about 0.75 sq. inches, between about 0.5 sq. inches and about 1.0 sq. inches, between about 0.75 sq. inches and about 1.25 sq. inches, any ranges between any of these values, or otherwise. This total cumulative open area can be accomplished using a single aperture **1310** or a plurality of apertures **1310**. If the total cumulative open area is less than 0.05 sq. inches, there may be an increase in the static pressure in the system, which may lead to the use of pumps (e.g., vacuum systems, blowers, or otherwise) that are louder and/or heavier to provide sufficient air flow. Excess noise may interfere with any voice recognition programming incorporated into the ophthalmic instrument. In various implementations, total cumulative noise level of the suction systems or pumps is no greater than about 50 dBa, no greater than about 40 dBa, no greater than about 35 dBA, no greater than about 30 dBa, no greater than about 25 dBa, no greater than about 20 dBa, or any other range between any of these values.

In the illustrated embodiment, the at least one aperture **1310** is an opening. As shown in FIG. **48**A, there is no extension or other protrusion extending from a periphery of any of the aperture **1310**. For example, in certain implementations no elongate tube extends from the periphery of the aperture. Likewise, in certain implementations no elongate tubular section extends from the periphery of the aperture. In certain implementations, no annular ring extends from the periphery of the aperture. Similarly, in certain implementations, no hollow cylindrical section (e.g., right circular cylinder or other cylinder having a hollow inner region) extends from the periphery of the aperture. Accordingly, in certain implementations the thickness of the periphery of the aperture **1310** may be no more than 1 mm thicker than the surrounding or adjacent surface which may, for example, be part of the transparent sections (or non-transparent sections) configured to be optically interfaced with the docking portion of the ophthalmic instrument. In certain implementations the thickness of the periphery of the aperture **1310** may less than 0.5 mm, less than 0.2 mm, or less than 0.1 mm thicker than the surrounding or adjacent surface which may, for example, be part of the transparent sections (or non-transparent sections) configured to be optically interfaced with the docking portion of the ophthalmic instrument. A surface surrounding each aperture **1310** can be generally planar, tapered, curved or combinations of these shapes. In certain implementations, the thickness of the periphery of the aperture **1310** may be the same thickness or substantially the same thickness as the surface surrounding each aperture **1310**. In some configurations, however, there may be an adapter, flange, tube, tubular section, or other connection feature possibly for connecting a device that facilitates air flow (e.g., vacuum, fan, etc.).

In some scenarios, it may be desirable to include a registration feature surrounding or at a periphery of one or more apertures **1310** (e.g., a periphery of individual apertures **1310** or a subset of apertures **1310**). The registration feature may register the mask **1300** in the cradle portion **1350** of the ophthalmic instrument. In some implementations, this registration feature can prevent the mask from moving within the cradle portion **1350** and/or act as a mechanical or electromechanical safety interlock that prevents the system from operating unless the mask **1300** is properly positioned.

As shown in FIG. **48**C, the OCT instrument or other ophthalmic system can include a cradle portion **1350** (also referred to herein as a docking portion) for receiving the mask **1300** (e.g., within a recess or slot or otherwise). The cradle portion **1350** may be integral with the other components of the ophthalmic system or a completely separate structure. The contours of a surface **1370** of the cradle portion **1350** can correspond to the contours of the mask **1300** (e.g., mirror each other or otherwise be counterparts). When assembled, the mask **1300** can be in close proximity to the surface **1370** of the cradle portion **1350** to increase or maximize the amount of air extracted from between the mask **1300** and the user. If there is a gap between the mask **1300** and the cradle portion **1350**, the suction system may be less efficient.

The cradle portion **1350** can include at least one aperture **1360** (e.g., one, two, three, four, or more) to facilitate air flow, for example suction, through the mask **1300**. When the mask **1300** interfaces with the cradle portion **1350**, each aperture **1310** of the mask **1300** can be in fluid communication with an aperture **1360** of the cradle portion **1350** (e.g., at least partially aligned) such that air flows through the aperture(s) **1310** of the mask **1300** and the aperture(s) **1360** of the cradle portion **1350**. At least one aspect of each aperture **1360** of the cradle portion **1350** (e.g., size, shape, and/or position of the apertures) can correspond with an aspect of a corresponding aperture **1310** of the mask **1300** to provide the alignment.

Each aperture **1360** of the cradle portion **1350** can be in fluid communication with a channel **1370** extending at least partially through the cradle portion **1350** (see FIGS. **49** to **51**). Each aperture **1360** can be in fluid communication with a separate channel **1370** or two more apertures **1360** can correspond to a single channel **1370**. In some configurations, each channel **1370** can extend from a first side **1352** of the cradle portion **1350** to an opposite side **1354** of the cradle portion **1350** (see FIG. **49**). A longitudinal axis of each channel **1370** can be substantially parallel to a longitudinal

axis L of the cradle portion **1350** (e.g., within about ten degrees of parallel). In other configurations, each channel **1370** can extend from a first side **1352** of the cradle portion **1350** to a lateral edge **1356** of the cradle portion **1350**. The channels **1370** may extend obliquely toward the lateral edge **1356** or may include one or more turns **1358** (see FIG. **50**). In other configurations, each channel **1370** can extend obliquely from a first side **1352** of the cradle portion **1350** to an opposite side **1354** of the cradle portion **1350** (see FIG. **51**). As shown in FIG. **51**, the channels **1370** may extend obliquely toward a centerline of the cradle portion **1350** and converge at a single outlet **1372** on the opposite side **1354** of the cradle portion **1350**.

As described above, it can be desirable to provide an air flow, for example suction, through the mask **1300** at a rate between about 0.001 and about 0.5 L/min. Below this range, air flow can be too low to prevent fogging. Above this range, air flow can be too high and may be uncomfortable or dry out the user's eyes. The channels **1370** can be sized to reduce the amount of static pressure and resistance the pumps have to overcome.

The cumulative cross-sectional area of the channels **1370** (taken transverse to a longitudinal axis of each respective channel **1370**) can fall within the same range as the cumulative open area of the apertures **1310** of the mask. The cumulative cross-sectional area of all of the channels **1370** can be between about 0.05 sq. inches and about 2.0 sq. inches. For example, the cumulative cross-sectional area of all of the channels **1370** can be between about 0.05 sq. inches and about 0.5 sq. inches, between about 0.25 sq. inches and about 0.75 sq. inches, between about 0.5 sq. inches and about 1.0 sq. inches, between about 0.75 sq. inches and about 1.25 sq. inches, any ranges between any of these values, or otherwise.

A length of each channel **1370** can be between about 0.5 inches and about 24.0 inches, for example, between about 0.5 inches and about 6 inches, between about 3 inches and about 9 inches, between about 6 inches and about 12 inches, between about 9 inches and about 15 inches, between about 12 inches and about 18 inches, between about 15 inches and about 21 inches, between about 18 inches and about 24 inches, any ranges between any of these values, or otherwise. For a curved or bent channel **1370** (e.g., as shown in FIG. **50**), the length can be measured along a centerline extending from a channel inlet to a channel outlet.

FIGS. **49** to **51** schematically illustrate systems **1400** with different channel configurations and positive air flow systems. The system **1400** may include one or more suction systems **1390** (e.g., venturi vacuum pump, rotary vane pump, diaphragm pump, piston pump, scroll pump, fan, etc.). For example, the system **1400** can include a single suction system **1390** (see FIG. **51**) or two suction systems **1390** for each side of the mask (see FIGS. **49** and **50**). The suction system(s) **1390** can be in fluid communication with the channel(s) **1370** (e.g., within the channel or external to the channel) through an air tight connection. The various features in FIGS. **49** to **51** can be used interchangeably. Although the systems below describe the use of suction systems **1390**, in other configurations, air flow may be passive or air may be delivered to the region between the mask **1300** and the user.

As shown in FIG. **49**, each aperture **1310** of the mask **1300** can be at least partially aligned with a corresponding aperture **1360** in the cradle portion **1350**. Each aperture **1360** of the cradle portion **1350** can be in fluid communication with a channel **1370**. Each of the channels **1370** can extend substantially linearly from a first side **1352** of the cradle portion **1350** to an opposite side **1354** of the cradle portion **1350**. Each channel **1370** can be in fluid communication with a suction system **1390** (illustrated as a venturi vacuum pump). Each suction system **1390** can be connected to a respective outlet end **1372** of a channel **1370** through a number of airtight ports or seals **1385** and air hoses **1380**. The suction systems **1390** can pump air from between the mask **1300** and the user, through the channels **1370**, and out of the suction systems **1390**.

As shown in FIG. **50**, each aperture **1310** of the mask **1300** can be at least partially aligned with a corresponding aperture **1360** in the cradle portion **1350**. Each aperture **1360** of the cradle portion **1350** can be in fluid communication with a channel **1370**. Each of the channels **1370** can extend from a first side **1352** of the cradle portion **1350** to a lateral side **1356** of the cradle portion **1350** through at least one turn **1358** (e.g., curved or angular turn). Each turn **1358** can form an angle of less than or equal to about 90 degrees and/or at least about 5 degrees, for example, less than or equal to about 75 degrees, less than or equal to about 60 degrees, less than or equal to about 45 degrees, ranges between these values, or otherwise. Each channel **1370** can be in fluid communication with suction system **1390** (illustrated as a blower). As shown, each suction system **1390** is positioned within a channel **1370**, but in other configurations, the suction systems **1390** may be positioned outside of the channels **1370**. The suction systems **1390** can pump air from between the mask **1300** and the user, through the channels **1370**, and out of the cradle portion **1350**.

As shown in FIG. **51**, each aperture **1310** of the mask **1300** can be at least partially aligned with a corresponding aperture **1360** in the cradle portion **1350**. Each aperture **1360** of the cradle portion **1350** can be in fluid communication with a channel **1370**. Each of the channels **1370** can extend obliquely from a first side **1352** of the cradle portion **1350** to an opposite side **1354** of the cradle portion **1350**. The channels **1370** can converge at a single outlet **1372**. The outlet **1372** can be in fluid communication with a suction system **1390** through a number of airtight ports/seals **1385** and/or air hoses **1380**. The suction system **1390** can pump air from between the mask **1300** and the user, through the channels **1370**, and out of the suction system **1390**.

TERMINOLOGY

While the invention has been discussed in terms of certain embodiments, it should be appreciated that the invention is not so limited. The embodiments are explained herein by way of example, and there are numerous modifications, variations and other embodiments that may be employed that would still be within the scope of the present invention.

For purposes of this disclosure, certain aspects, advantages, and novel features of the invention are described herein. It is to be understood that not necessarily all such advantages may be achieved in accordance with any particular embodiment of the invention. Thus, for example, those skilled in the art will recognize that the invention may be embodied or carried out in a manner that achieves one advantage or group of advantages as taught herein without necessarily achieving other advantages as may be taught or suggested herein.

As used herein, the relative terms "temporal" and "nasal" shall be defined from the perspective of the person wearing the mask. Thus, temporal refers to the direction of the temples and nasal refers to the direction of the nose.

As used herein, the relative terms "superior" and "inferior" shall be defined from the perspective of the person

wearing the mask. Thus, superior refers to the direction of the vertex of the head and inferior refers to the direction of the feet.

As used herein, the relative terms "anterior" and "posterior" shall be defined from the perspective of the person wearing the mask. Thus, anterior refers to the direction of the user's face and inferior refers to the direction of the back of the user's head.

As used herein, the relative terms "proximal" and "distal" shall be defined from the perspective of the person near the mask. Thus, proximal refers the direction of the person and distal refers to the direction away from the person.

The term mask is used herein to include an interface for the subject that is to be disposed between the patient's eyes and the ophthalmic instrument. This interface need not be secured to the subject when the subject is away from the instrument. Similarly, the term wear or worn is used in connection with the mask being disposed with respect to the subject's head and/or face such that the mask is between the patient's eyes and the ophthalmic instrument when the exam is performed. The term wear or wearer therefore applies to the subject regardless of whether (i) the interface is secured to the subject when the subject is away from the instrument or (ii) the subject uses the mask when the mask is inserted into the docking portion or receptacle on the ophthalmic instrument and the interface is not secured to the subject when the subject is away from the instrument.

Terms such as "above," "below," "bottom," "top," "side," "higher," "lower," "upper," "over," and "under," are from the perspective of the person wearing the mask. Thus, upper is closer to the vertex of the head than lower when the person is using the OCT device.

Conditional language, such as "can," "could," "might," or "may," unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments include, while other embodiments do not include, certain features, elements, and/or steps. Thus, such conditional language is not generally intended to imply that features, elements, and/or steps are in any way required for one or more embodiments.

The terms "comprising," "including," "having," and the like are synonymous and are used inclusively, in an open-ended fashion, and do not exclude additional elements, features, acts, operations, and so forth. Also, the term "or" is used in its inclusive sense (and not in its exclusive sense) so that when used, for example, to connect a list of elements, the term "or" means one, some, or all of the elements in the list.

The terms "approximately," "about," and "substantially" as used herein represent an amount close to the stated amount that still performs a desired function or achieves a desired result. For example, the terms "approximately", "about", and "substantially" may refer to an amount that is within less than 10% of the stated amount, as the context may dictate.

The ranges disclosed herein also encompass any and all overlap, sub-ranges, and combinations thereof. Language such as "up to," "at least," "greater than," "less than," "between" and the like includes the number recited. Numbers preceded by a term such as "about" or "approximately" include the recited numbers. For example, "about 450 nm" includes "450 nm."

Components can be added, removed, and/or rearranged. Further, the disclosure herein of any particular feature, aspect, method, property, characteristic, quality, attribute, element, or the like in connection with various embodiments can be used in all other embodiments set forth herein. Additionally, it will be recognized that any methods described herein may be practiced using any device suitable for performing the recited steps.

Moreover, while illustrative embodiments have been described herein, the scope of any and all embodiments having equivalent elements, modifications, omissions, combinations (e.g., of aspects across various embodiments), adaptations and/or alterations as would be appreciated by those in the art based on the present disclosure. The limitations in the claims are to be interpreted broadly based on the language employed in the claims and not limited to the examples described in the present specification or during the prosecution of the application, which examples are to be construed as non-exclusive. Further, the actions of the disclosed processes and methods may be modified in any manner, including by reordering actions and/or inserting additional actions and/or deleting actions. It is intended, therefore, that the specification and examples be considered as illustrative only, with a true scope and spirit being indicated by the claims and their full scope of equivalents.

Any methods disclosed herein need not be performed in the order recited. The methods disclosed herein include certain actions taken by a practitioner; however, they can also include any third-party instruction of those actions, either expressly or by implication.

What is claimed is:

1. An ophthalmic instrument for performing an eye exam of a subject, the instrument comprising:

a light source and optics configured to direct an incident light beam onto the subject's eyes and receive a reflected or scattered light beam from the subject's eyes;

a docking portion configured to receive a mask;

an attachment portion configured to interface with the mask thereby restricting movement of said mask, and

a shutter disposed in a first position to block a path to said light source and optics when the mask is not mated with said docking portion, said shutter configured to be moved from said first position into a second position when the mask is mated with said docking portion so as to permit incident light beam from said light source onto the subject's eyes and for said optics to receive a reflected or scattered light beam from the subject's eyes.

2. The instrument of claim **1**, further comprising an actuator configured to move said shutter.

3. The instrument of claim **1**, wherein said shutter is configured to moved manually.

4. The instrument of claim **1**, wherein said shutter is configured to be moved by introducing said mask to said docking portion.

5. The instrument of claim **1**, further comprising one or more sensors disposed to sense that the mask has mated with said docking portion.

6. The instrument of claim **5**, wherein said optics in said instrument are configured to move, said movement being stopped when said shutter is moved from said first position and no mask is detected as being mated with said docking portion.

7. The instrument of claim **5**, wherein said instrument is configured not to perform a measurement of an eye when no mask is detected as being mated with said docking portion.

8. The instrument of claim **5**, wherein said instrument is configured not to move parts within said instrument when no mask is detected as being mated with said docking portion.

9. The instrument of claim **5**, wherein the one or more sensors comprises an electrical contact switch.

10. The instrument of claim **5**, wherein the one or more sensors comprises an optical switch.

11. The instrument of claim **5**, wherein the one or more sensors comprises a resistance-based switch.

12. The instrument of claim **1**, wherein the attachment portion is positioned at a periphery of the docking portion.

13. The instrument of claim **1**, wherein the docking portion comprises a pair of apertures spaced apart by a bridge, the attachment portion positioned on the bridge.

14. A system comprising:

the instrument of claim **1**, wherein the attachment portion comprises a retention member; and

the mask comprising a corresponding engagement feature configured to interface with the retention member.

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